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THE MONSTER WHITE STAR LINER OCEANIC LAUNCHED AT BELFAST, IRELAND.

Our frontispiece shows the launching of the White Star Line steamship Oceanic at the yard of Harland & Wolff, Belfast, Ireland. This event took place on Saturday, January 14, so our readers will appreciate that some quick work was necessary to get the instantaneous photograph of the launch in print in this issue.

WHITE STAR TWIN-SCREW S.S. OCEANIC LEAVING THE WAYS AT HARLAND & WOLFF'S.
(*Photographed for Marine Engineering by Geo. M. Roche, Esq.*)

In dimensions the Oceanic exceeds any vessel afloat or built. In detail they are: Length over all, 704 ft.; length between perpendiculars, 685 ft.; beam, 68 ft.; depth moulded, 49 ft. 6 in.; extreme depth, 68 ft.; load draught, about 32 ft.; gross tonnage, 17,040 tons; maximum displacement, about 30,000 tons. She is designed to maintain a sea speed, day in and day out, of 20 knots, and to be capable of an average rate of 21 knots if let out.

The speed decided upon is less than that of other vessels now in the trade and considerably less than that of the 23-knot vessel under construction for the Atlantic trade for one of the German lines. The new vessel will be rather speedier, however, than the two largest ships of the line now in service, the Teutonic and Majestic. On account of the moderate speed demanded the engine power will be less than

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that of the big Cunarders, Campania and Lucania. It is estimated at 28,000 I. H. P. divided into two sets driving twin screws.

In general appearance the Oceanic will follow the lines of the Teutonic and Majestic. She will have three pole masts and two large elliptical stacks. She will have also a straight stem and an elliptical stern and will have a pleasing amount of sheer. She will not be fitted with turtle back decks forward and aft as in other ships of the line, for the ends will be so high that these will be unnecessary. She will have seven decks, five of which are carried from stem to stern and all of them designed to add to the strength of the vessel. These are in order: Lower orlop deck, orlop deck, lower deck (which will be about the water line), middle deck, upper deck, promenade deck and boat deck. Surmounting this in front of the forward funnel, over the pilot house, there will be the navigating bridge. The photographs published herewith give a very clear idea of the hull design. It will be noticed that the forefoot is cut away and that the vessel is very fine aft and that there is a screw opening in the deadwood, as is usual in twin screw vessels built at this yard. This permits of the propellers being placed close to one another, and at the same time gives better opportunity for the water to reach the blades. The propeller shafts and the stern brackets are enclosed by the skin plating. The vessel will have twin screws, driven by inverted triple-expansion four-cylinder, four-crank engines, with cylinders; H. P. 47 1-2 in.; I. P., 79 in., and two L. P. 93 in., all with 72 in. stroke. Piston valves will be fitted to the H. P. and I. P. cylinders and double-ported valves to the L. P. cylinder. Independent cylindrical condensers will be used and the air pumps will be driven from the L. P. crossheads in the usual way. Stephenson link motion will be used. Great care has been taken in putting the very highest class material into the vessel. The crank shafts will be fluid compressed steel, built up, 25 in. dia. in the bearings and 26 in. in the pins. Line shafts will be 23 3-4 in. dia., and propeller shafting 25 1-4 in., all of which will be hollow. The propellers will have gun metal hubs and detachable manganeze bronze plates, three blades to each propeller. The diameter will be 22 ft. 3 in. The boilers will be of the regular cylindrical double-ended fire tube type, placed in groups athwartships, the largest of them having diameter of 16 ft. 6 in.

With the launch of a vessel of this class comes the inevitable comparisons with her predecessors. The vessel in this case with which a comparison most naturally follows is the Great Eastern, launched in 1858 and long ago gone to the scrap heap. Her dimensions were: Length, 692 ft.; beam, 82 ft. 6 in.; depth, 58 ft., and gross tonnage, 19,000 tons. She was fitted with both paddle and screw engines of about 8,000 aggregate horse power, and had a sea speed of about 13 knots. In recent days the vessels for direct comparison can be taken from the Cunard and North German Lloyd fleets. Of the former, the Campania is in length 620 ft., beam 65 ft., and 12,950 gross tons; while the Kaiser Wilhelm der Grosse is in length 648 ft., beam 66 ft., and 14,000 gross tons.

VIBRATIONS OF STEAMSHIPS AND METHODS OF BALANCING MARINE ENGINES—I.

BY C. H. PEABODY, B. Sc.

All steamships tremble or vibrate more or less when the engines are running. It is only when the vibrations are excessive that the trembling attracts attention, and as this usually occurs when a powerful engine is placed in a lightly built ship, it has been commonly considered that the trembling is due to weakness of the hull. Should the hull be strengthened in accordance with this idea the trembling will probably be reduced, which naturally is considered as a confirmation of the assumed reason for the trembling. Yet some lightly built ships which are driven by powerful engines do not tremble excessively, and, on the other hand, some strong ships vibrate violently; and, again, a ship may vibrate violently, and even dangerously, at some speeds and be fairly quiet at other speeds. Thus the U. S. cruiser Columbia on her trial trip showed a very disagreeable amount of vibration when running at about 19 knots, but was noticeably quiet at full speed. The greatest difficulty has been experienced from vibrations of torpedo boats, in which high speed is sought by the combination of powerful high speed engines in light and slender hulls. Such boats are liable to vibrate excessively at several speeds, such as half speed, three-quarter speed and full speed, and at intermediate speed the vibration may be of little importance.

These facts point to the true explanation of the cause of vibration of the hull of a ship, namely, the coincidence of the time of revolution of the engine to the natural time of vibration of the hull. For the hull of a ship, especially of an iron or steel ship, is an elastic body with a natural time of vibration; just as a steel rod or a tense cord has a natural time of vibration, which can be recognized by the musical note emitted when the rod or cord is struck. The time of vibration of a rod depends upon and can be calculated from its form and dimensions and its weight and elasticity. And in like manner the time of vibration of the hull of a ship depends on its size and form, and on its construction and the distribution of the weights carried, such as the weight of the hull, the machinery and equipment and the cargo or other burdens carried. The structure of the hull is so complicated and the distribution of the weights is so irregular that no one has ventured to make a theoretical discussion of the time of vibration of a ship. But the fact that a ship may in a general way be likened to a beam or girder allows us to establish certain semi-logical equations which can be used to estimate the probable time of vibration of a ship from the observed time of vibrations of ships of the same class.

To make this matter clear it is necessary to look somewhat closely into the vibrations of bodies that are carried or supported on springs. For example, the time of vibration of a wagon body depends on the stiffness of the springs and on the weight of the wagon body and the load in it. But the deflection of the springs is a measure at once of the stiffness of

T. S. S. OCEANIC FULLY WATERBORNE.

T. S. S. OCEANIC ALL CLEAR READY FOR LAUNCHING, JANUARY 14, 1899.
(*Photographs taken for Marine Engineering by Geo. M. Roche, Esq.*)

the springs and of the load on them, so that the number of vibrations per minute can be determined as soon as the deflection is known. If the deflection of the spring in feet is d, then the time of a single vibration in seconds is

$$t = \pi \sqrt{\frac{d}{g}}$$

when $\pi = 3.1416$ is the ratio of the circumference of a circle to its diameter and $g = 32.16$ is the acceleration due to gravity, or the distance a body will fall freely from rest in one second.

Now a girder or beam when loaded may act as a spring, and its deflection will be proportional to the load on it; but it is also affected by the length and other dimensions of the beam, thus the deflection is proportional to the cube of the length of the beam and is inversely proportional to the moment of inertia of the cross section of the beam. The last term, *moment of inertia*, is one that is developed in the theory of beams. To express these facts in a formula we may write

$$d \propto \frac{W L^3}{I}$$

when W is the load on the beam, including its own weight, L is the length of the beam, and I is the moment of inertia. Replacing the deflection in the general equation for the time of vibration of a spring by the form just written, we have

$$t \propto \sqrt{\frac{W L^3}{I}}$$

Applying this to the time of vibration of the hull of a ship, which can be likened, as has been said, to a beam or girder, we will find that W, the weight, may be replaced by the displacement of the ship in tons, that L is the length of the ship in feet and that I is the moment of inertia of the midship section. It will be sufficient to note that for the present purpose the moment of inertia may be calculated by multiplying the area of the section of each longitudinal member of the ship (such as keel, stringer, shell plate or deck plate) by its distance from the neutral axis of the midship section.

Following such a line of reasoning, both Normand and Schlick have independently proposed the following formula for calculating the time of vibration of a ship:

$$N = C \sqrt{\frac{I}{D L^3}},$$

in which

N = number of single vibrations per minute.

D = displacement in tons.

L = length in feet.

I = moment of inertia of midship section (areas in square inches, distances in feet).

C = a constant, depending on the class of the ship.

Schlick gives the following values for the constant C:

Torpedo-boat destroyers.....	$C = 156850$
Large passenger steamers.....	$C = 14350$
Cargo boats.....	$C = 12790$

Schlick further asserts that any ordinary variation in the distribution of weights has little effect on the value of the constants. But a concentration of weights either at the ends or at the middle of a ship will give slower vibration, since such a concentration leads to a greater bending or deflection of the hull of the ship on account of the manner of loading.

A notable example of the change of time of vibration of a ship came under the attention of the writer. A certain screw ferryboat was built with fuller lines at the ends than was intended. The consequence was that the boat floated too high and the deck at the ends was a foot or more higher than the floats of the slips at the landings. To bring the boat down, about 300 tons of stone ballast were placed in the ends of the boat, which so decreased the number of vibrations per minute as to bring about a close coincidence with the time of rotation of the engine and dangerous vibrations ensued. The difficulty was overcome by removing the ballast and lowering the deck at the ends.

The vibrations thus far considered are vertical vibrations of the whole structure of the ship, which may be likened to the vibrations of a thin plate. Fig. 1 represents the simplest form of vibration of such a thin plate, on an exaggerated vertical scale. a c b represents the neutral position of the plate when at rest, and a' c' b' and a'' c'' b'' represent extreme positions when vibrating. At certain points,

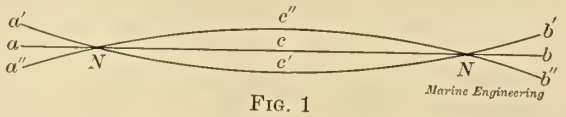


FIG. 1

N and N, near the ends, there is no vibration; such points are called nodes. The place where the vibration is greatest is known as a loop. The nodes of a thin plate of uniform section are somewhat less than a quarter of its length from the ends. The location of the nodes of vibrations of ships have not been well located. Schlick gives the following as the location of nodes of fast cruisers and dispatch boats:

Forward node—0.310 to 0.365 of length aft of forward perpendicular.

Aft node—0.231 to 0.365 of length forward of aft perpendicular.

Fig. 1, with two nodes and one loop, represents the simplest and slowest vibration that can be given to a plate or a rod. A rod which is supported at the nodes can be set into vibration by striking it with a light hammer or mallet, or by drawing a fiddle bow across it. If the rod is supported at three points or nodes, one at the middle and two nearer the ends, it can be made to vibrate with two loops; the vibrations will then be more rapid. Again, a rod may be made to vibrate with four nodes and three loops at still a higher rate, and so on. In like manner a ship may be set into vibrations of a higher order and of greater frequency with three or four nodes and two or three loops. Such vibrations are much less easily set up and are less dangerous than the simple vibrations with two nodes; consequently our attention will be given mainly to the simplest vibrations.

In addition to the vibrations of the entire structure

of the ship, there are certain local vibrations which may occur, and which must not be confused with the vibrations of the hull. As examples of local vibrations we may instance panting near the bow or stern, where the shell plating is but little curved; vibrations at or near the rudder post and vibrations under the engine.

The general form of the hull of a ship is so rounded and reinforced by the transverse framing as to be stiff and rigid. But near the bow the surface is flatter and is likely to be affected by the varying pressure of the water as the ship pitches among waves. The flat surface, if not stiffened by special construction, is likely to spring out and in; such action is called *panting*, and can be prevented by working in an additional longitudinal stringer between the usual longitudinal members which extend throughout the length of the ship. The panting stringers on the two sides of the bow may be reinforced by tying them together, or better, by working a flat or deck on them. Panting may also occur near the stern, but in general the form of a ship near the stern is less likely to be affected by panting.

The whole structure of the frame of a ship near the rudder post is weak transversely, due to fining away the hull so that water can flow freely to the propeller and the rudder. Should the propeller be out of balance dangerous vibrations may be set up near the stern post, especially if the natural time of vibration of the thin and flattened structure between the keel and the rudder post coincides nearly with the time of revolution of the engines. There is, however, no excuse for lack of balance of the propeller and its shaft, and such vibrations are not of importance on well built ships when steaming ahead on a straight course. But when a ship is turning the propeller blades on the outer side of the curved course reach out into undisturbed water and meet with greater resistance than the blades at the inside, which work in the wake of the ship. The fluctuation of pressure exerted by a propeller blade which works now in undisturbed water and again in the wake gives rise to a vibration of the stern of the ship which may be dangerous when the helm is thrown hard over at full speed. There is, of course, no remedy for this; fortunately there is seldom necessity for turning sharply at full speed.

Some shallow draught vessels with quick running engines have shown a serious vibration of the bottom of the hull directly under the engines. This vibration, which is like that of a tense membrane—for example, the head of a drum—is like the vibration of the hull in general, in that it is due to a coincidence of the time of vibration of the bottom framing and plating with the time of revolution of the engine. It can be prevented by stiffening the bottom framing and so increasing the number of vibrations per minute. But as the natural method of stiffening the framing is to increase the depth of the floors, it may be difficult to provide for such stiffening. If the engine foundation is deficient in strength it may yield to the forces exerted by the engine; such a movement of the engine should not be confused with vibrations of the bottom of the hull.

Returning to the vibrations of the whole structure of the hull of a ship, which vibrations are at once more common and more difficult to deal with, it is necessary to show the true course of these vibrations. They are not due to the direct pull and thrust of the steam pressure working on the piston, for these direct forces are taken up by the engine frame, but they are due to the reciprocation of the moving parts of the engine, such as the piston, piston-rod, crosshead and connecting-rod. These parts are at rest at the beginning of a stroke, and can be set in motion only by the action of an unbalanced force. This force comes of course from the steam pressure on the piston and must be subtracted from the total force of the steam in order to find the effective force which is applied to the crank pin and turns the crankshaft. The effective force is taken up by the engine frame, but the unbalanced force is resisted by the framing of the ship. It will be noted that the force required to accelerate the piston and attached parts is independent of the steam pressure and of the work done by the steam in the cylinder. This force depends on the weight of the reciprocating parts, on the length of the stroke, and on the number of revolutions per minute. The vibrations will then be the same for the same speed of the engine, whether it is running under full load, as when driving the ship at full speed; whether it is running light, for example, with the propeller removed, or whether it is rotated by some external power applied to the shaft, if that is possible. The accelerating force is greatest at the beginning of the stroke, diminished until it is zero near the middle of the stroke, and then changes into a resistance which brings the piston to rest at the end of the stroke. The calculation of the accelerating and retarding forces which produce the vertical motion of the reciprocating parts of the engine is somewhat tedious, but presents no particular difficulty, if properly systematized, and should be made for all high speed engines in the determination of the strength of the engine.

Note. The displacement of the piston from the beginning of the stroke in Fig. 2 is;

$$A\,B = A\,E + E\,O - B\,D - D\,O$$
$$= A\,E + E\,O - \sqrt{\overline{BC}^2 - \overline{CD}^2} - DO.$$

If $B\,C = l$ = length of connecting rod;
$C\,O = r$ = length of crank;
$A\,B = s$ = displacement of the piston,
and $C\,O\,D = a\,t$ = crank angle; then

$$s = l + r - \sqrt{l^2 - r^2 \sin^2 a\,t} - r \cos a\,t.$$

Here a is the angular velocity of the crank, that is the angular

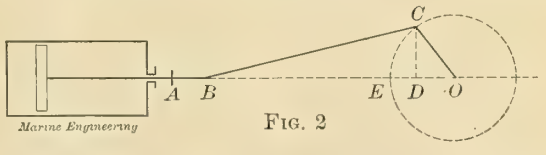


FIG. 2

space swept over in a second, and can be calculated by the expression

$$a = \frac{2\,\pi\,N}{60}$$

when N is the number of revolutions per minute.

The velocity of the piston at any position s from the beginning of the stroke is;

$$v = \frac{d\,s}{a\,t} = \frac{a\,r^2 \sin a\,t \cos a\,t}{\sqrt{l^2 - r^2 \sin^2 a\,t}} + a\,r \sin a\,t$$

$$\therefore v = a\,r \sin a\,t \left\{ 1 + \frac{r \cos a\,t}{\sqrt{l^2 - r^2 \sin^2 a\,t}} \right.;$$

and the acceleration is

$$f = \frac{d^2\,s}{d\,t^2} = a^2\,r \cos a\,t \left\{ 1 + \frac{r \cos a\,t}{\sqrt{l^2 - r^2 \sin^2 a\,t}} \right.$$

$$+ a\,r \sin a\,t \left\{ - a\,r \sin a\,t\,[l^2 - r^2 \sin^2 a\,t]^{-\frac{1}{2}} \right.$$

$$\left. \left. + r \cos a\,t\,[(l^2 - r^2 \sin^2 a\,t)^{-\frac{3}{2}} (a\,r^2 \sin a\,t \cos a\,t)] \right\}$$

$$\therefore f = a^2\,r \left\{ \cos a\,t + \frac{r(\cos^2 a\,t - \sin^2 a\,t)}{\sqrt{l^2 - r^2 \sin^2 a\,t}} + \frac{r^3 \sin^2 a\,t \cos^2 a\,t}{(l^2 - r^2 \sin^2 a\,t)^{\frac{3}{2}}} \right\}$$

If the connecting rod is very long compared with the crank, or better still, if the engine has a slotted crosshead, then the velocity and acceleration become,

$$v = a\,r \sin a\,t$$

$$f = a^2\,r \cos a\,t$$

If W is the weight of the reciprocating parts and g is the acceleration due to gravity, then the force required to produce the motion of the reciprocating parts is

$$F = f\,\frac{W}{g}$$

The method of calculating the forces required to produce the motion of the reciprocating parts, i. e., the piston, piston-rod, crosshead and connecting-rod, is given in the preceding note. It will now be sufficient to note that the force is less at the lower or crank end than it is at the upper or head end of a vertical marine engine; this fact will become of importance in the consideration of certain methods of balancing engines.

The action of the fluctuating forces which produces the motion of the piston and attached parts of a single cylinder engine may be likened to a man standing on his toes and teetering up and down. If a man stands thus at the middle of a plank which is supported at the nodes (N and N, Fig. 1) he may readily throw the plank into violent vibration. In like manner a single cylinder engine placed at the middle of a ship may produce dangerous vibrations. If such an engine is placed at a node, that is at about a quarter of the length of the ship from the stern, it can have little effect in producing vibration.

Suppose now that an engine has two cylinders placed side by side, and with the cranks opposite, similar to the high-pressure and intermediate cylinders of Fig. 6, and that the weight of the reciprocating parts is the same for each cylinder. Then there

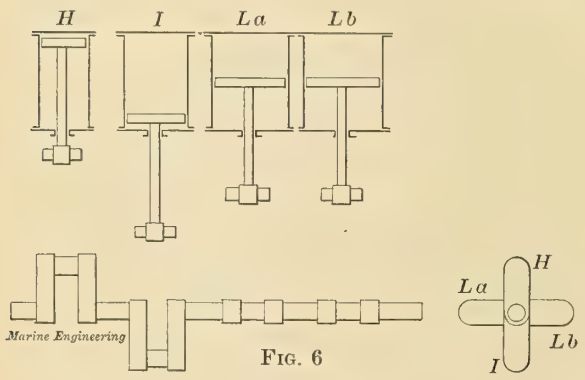


FIG. 6

will be very nearly a balance of the vertical forces producing motion of the piston, for one piston will be coming up as the other is going down. The balance would be exact if the engine had slotted crossheads; with short connecting rods commonly used on marine engines the force for the piston starting down will be considerably larger than for the piston which is going up. Nevertheless such an engine placed at the middle of a ship would produce very little vibration. Since the turning moment which such an engine would exert on the crankshaft would be as irregular as that of a single cylinder engine, two-cylinder engines with opposite cranks have never been used to propel ships. When that device has been used for balancing engines four cylinders have been used, as will be explained later in connection with Fig. 6.

Suppose that such an engine with two opposite cranks were placed at the node of a ship, so that one cylinder is as much ahead as the other is aft of the node; its action may be likened to that of a man standing astride of a node of a plank and throwing his weight now on one foot and then on the other. By such action he could readily throw the plank into vibration, and so also will the engine produce violent shaking of the ship when at or near a node. This engine is sometimes said to be in standing balance, but not in running balance, because it tends to rock its foundation when running.

It consequently appears that there are two ways in which a ship may be thrown into simple vibrations, like Fig. 1, with two nodes and one loop, i. e., either by an unbalanced engine at a loop (that is near the middle), or by an engine which is in standing but not in running balance, and which is at or near a node.

The ordinary three-cylinder triple-expansion engine with the cranks at 120 deg. is neither in standing nor in running balance. Schlick says that if the weight of the low pressure piston and its piston-rod, crosshead and connecting-rod is taken as unity, then the weight of the corresponding parts for the intermediate cylinder is 0.82, and for the high pressure cylinder is 0.73. It seems, therefore, that it would not be difficult to put such an engine into standing balance by adding to the weight of the intermediate and high pressure pistons. The questions arises whether it is worth while to add sufficient weight to the engine for this purpose. In the first place it is evident that it will not be worth while for a slow running engine, for such an engine will not produce much vibration in any case, and the three cranks equally spaced around the circle will give a very even turning effort on the crankshaft. For slow and moderate speeds the three-crank triple engine has a deserved good reputation for smoothness of action; three-crank compound engines with two large and one small cylinder were used successfully in large ships like the Cunarder Etruria before triple engines were introduced.

If a three-crank triple engine with the usual proportion of parts should be placed at the middle of a ship, then the lack of standing balance may give rise to serious vibrations, which could be much reduced, if not eliminated, by making the weights of the pistons equal. But engines are seldom placed in the

middle of a ship, and such a balancing of the engine for that purpose is seldom called for.

The engine is usually somewhere near a node, and then it will be a question whether or not advantage will come from equalizing the weights of the piston. If the weights of the reciprocating parts have the proportion given by Schlick, namely,

Low pressure piston, piston-rod, crosshead and connecting-rod	1
Intermediate piston, piston-rod, crosshead and connecting-rod	0.82
High pressure piston, piston-rod, crosshead and connecting-rod	0.73

then, as pointed out by him, there will be very small vibration due to rocking couples when the engine is placed forward of a node, as shown by Fig. 3, with the cylinders arranged in the customary order, pro-

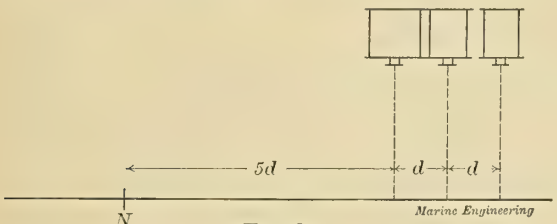


FIG. 3

vided that the axis of the low pressure cylinder is five times the common distance between the axis of the cylinder, as shown by that figure. If this is so, the moment of the weight of the reciprocating parts for each cylinder, with regard to an axis through the node, will be

$$5\ d\ W,$$

where d is the common distance between the axis of the cylinder and W is the weight of the reciprocating parts of the low pressure cylinder. This is evident from the following:

Low-pressure cylinder	$5\ d \times$	$W = 5\ d\ W$
Intermediate cylinder	$6\ d \times 0.82$	$W = 4.92\ d\ W$
High-pressure cylinder	$7\ d \times 0.73$	$W = 5.11\ d\ W$

Note. To show that this equality of moments will avoid rocking couples, we may bear in mind that the acceleration for harmonious motion, as has already been shown, is

$$f_3 = a^2\ r\ cos\ a\ t = a^2\ r\ cos\ A$$

where A is the angle the crank makes with the line of dead points as shown by Fig. 4, for the low pressure cylinder. The intermediate crank may be 120° ahead, as at I, and the acceleration of its piston will be

$$f_2 = a^2\ r\ cos\ (A + 120°).$$

The acceleration for the high pressure piston will be

$$f_1 = a^2\ r\ cos\ (A + 240°).$$

Expanding and reducing we have

$$f_3 = a^2\ r\ cos\ A$$
$$f_2 = a^2\ r\ (cos\ A\ cos\ 120° - sin\ A\ sin\ 120°)$$
$$f_1 = a^2\ r\ (cos\ A\ cos\ 240° - sin\ A\ sin\ 240°).$$

But both cos 120° and cos 240° are equal to − sin 30°, while sin 120° = cos 30° and sin 240° = − cos 30°; so that our equation becomes,

$$f_3 = a^2\ r\ cos\ A$$
$$f_2 = a^2\ r\ (-sin\ 30°\ cos\ A - cos\ 30°\ sin\ A)$$
$$f_1 = a^2\ r\ (-sin\ 30°\ cos\ A + cos\ 30°\ sin\ A).$$

The accelerating force for the low pressure cylinder is $f_3\ W$ and the moment of the force about an axis at the node is $5\ a f_3\ W$. The moments of the force for the other cylinder is found in a similar way, taking account of the weights of the reciprocating parts and the distances of the cylinders from the nodes. Carrying through

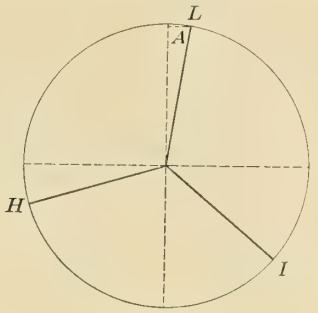


FIG. 4

this work and remembering that cos 30° = ½ we shall have for the moments for the three cylinders (or rather for their reciprocating parts)

$$5\ d\ W f_3 = 5\ d\ W\ a^2\ r\ cos\ A$$
$$6\ d \times 0.83\ W f_2 = 4.91\ d\ W\ a^2\ r\ (-\tfrac{1}{2}\ cos\ A - cos\ 30°\ sin\ A)$$
$$7\ d \times 0.72\ W f_1 = 5.11\ d\ W\ a^2\ r\ (-\tfrac{1}{2}\ cos\ A + cos\ 30°\ sin\ A).$$

The sum of these three equations is very nearly zero, consequently there will be very little influence at the node to produce shaking or vibration. Of course the same result would have come out if any other of the cranks had been taken at the angle A with the line of dead points.

It thus appears that the condition necessary in order that a three-crank engine (with the cranks at 120 deg.) may not produce shaking when placed near a node, is that the moment of the weight of each of the reciprocating parts with regard to an axis at the node shall be the same. If this method of avoiding vibration is to be used, then the location of the nodes of a projected ship must be known, and the location of the engine with regard to the node must be under the control of the designer. Neither of these conditions can be counted upon by a designer, for the location of the nodes is not well known and the location of the engine is commonly controlled by the necessity of trimming the ship. When the location of the nodes of ships has been determined, this method of avoiding vibration may be valuable in some cases, especially as the designer may control the moments of the reciprocating parts to some extent by loading the lighter pistons and by the spacing of the cylinders. At any rate it offers an explanation of the disappointment of some engineers who have obtained a standing balance for a three-crank engine by making all three pistons of equal weight; as the engine is likely to be near a node, such an arrangement may give worse rather than better results, so far as vibrations are concerned.

The Cramps are now figuring on a 700 ft. dry dock on their Kensington property at Philadelphia.

A bill for the construction of the Nicaragua Canal has passed the House of Representatives at Washington.

The U.S. cruiser Albany was successfully launched at the yard of Armstrong, Whitworth & Co., Newcastle-on-Tyne, Eng., January 14. The vessel is a sister ship of the New Orleans, which made a very good record during the Spanish war.

PORTABLE PNEUMATIC RIVETERS AS USED BY THE CHICAGO SHIPBUILDING COMPANY.*

BY W. I. BABCOCK.

In 1893, in a paper on shipyard appliances, read before the Engineering Congress at Chicago, Professor Durand said: "Among the various mechanical aids which would be of distinct value to the shipbuilder, few would stand higher or be more acceptable than one which would efficiently replace the ship riveter's gang."

As the result of three years of constant experimenting, into which the Chicago Shipbuilding Company was forced by the unreasonable demands and frequent strikes of its riveters, the problem has been entirely solved. We are able to drive every rivet in a ship by power machines, operated by unskilled labor, and in the last ship we have built over 250,000 have been so driven out of 340,000. But that our air capacity was insufficient, the proportion would have been greater. This paper is intended as a history of our experience in developing the portable machines.

When we began, we had already for some months been using with great success a stationary steam riveter of the ordinary type, with a horizontal ram and a 5 ft. gap, for certain portions of the work, which could be easily brought to the machine. This would include the floor plate with brackets, bilge frames and longitudinal stiffeners, as well as the side frames and belts amidships with the beam brackets thereon, and, generally, any portion of the vessel which can be riveted up and carried to the ship in one piece. The handling at the riveter is done by a chain hoist working on an overhead trolley. With this machine we have driven over 1,800 rivets in a day of 10 hours at a cost of not over 1-2 cent apiece, or a saving of 2 1-4 cents each over the scale rate for driving such rivets by hand.

In fixing first upon the power to be used for portable machines, we naturally and promptly decided upon compressed air. We were, of course, aware that hydraulic riveters had been used for years in England to a greater or less extent, and somewhat also in this country, but we were afraid that the severe winter climate of Chicago might operate against them. The more important consideration, however, was that air could be used for caulking and chipping hammers and drills or reamers, so that a compresser plant for the yard was a necessity in any event, and we did not want to go to the expense of an hydraulic plant in addition if it could be avoided.

As naturally, also, seeking for portable riveters, we first applied to the manufacturers of the compression bow machines so extensively used in bridge shops, and finally found one maker who guaranteed the performance of a machine with a horse-shoe frame having a gap of 72 in., which we needed to drive the bottom rivets in a 6 ft. center keelson. This was a matter of some difficulty, as the gap usually used was not more than 42 in., and, in fact, the first machine furnished us, in February, 1896, proved too light for the work and had to be replaced by a heavier one, the weight finally reaching over 2,500 lb. A similar tool, with the gap cut down to 45 in., weighed over 1,700 lb., and a very little experience showed that even with this lighter weight the difficulty of handling was too great to permit of the economical use of this kind of a machine for more than a very small portion of the ship.

In the spring of 1896 we heard that at the works of the Lassig Bridge and Iron Company, in Chicago, some experimental rivets had been driven with an ordinary pneumatic caulking hammer. Trying this at once in our yard, we found the method perfectly feasible, though severe on the man using the hammer. It was also almost impossible to hold on to the rivets by the ordinary heavy hammer, the blows of the pneumatic hammer on the point being so heavy and continuous that the holder-on was unable to keep his hammer from being fairly "jarred" off the head of the rivet. This difficulty, however, was quickly obviated by the use of a pneumatic holder-on which we devised, of the simplest construction, being only a cylinder into which air is admitted, forcing out a piston, the rod of which is cupped out to go over the rivet head. The parallel arrangement of the longitudinals in the double bottom of our lake ships made it easy to obtain a bearing or resistance for the cylinder itself, a piece of pipe of the proper length being screwed to it. This made a perfectly practicable method, and many rivets were driven by it. We still use it to some extent for odd rivets or in certain contracted spaces.

The next step was naturally the connection of the hammer and holder-on by a horse-shoe frame or bow, forming a single machine. As the bow has only to resist the pressure of the holder-on and the blows of the hammer, it can be made of very light construction and is very easily handled and moved to various parts of the ship. Nearly all of the inside rivets in our ships are now driven by these machines.

A variation in the device is to mount the hammer itself as a piston in a cylinder, to which air is admitted to force out the hammer as the point of the rivet is beaten down, using a plain die on the other side, which die can, therefore, be made small to get into contracted places.

The weights of the whole arrangement for various depths of gap, taken from actual machines in use in our yard, are as follows: 9 in., 83 lb.; 51 1-2 in., 160 lb.; 70 in., 220 lb. In the larger ones the bow is made of a plain piece of wrought-iron pipe.

In some cases the riveter is suspended by a chain hoist from a trolley carried on a beam supported by a pair of A frames. As a general rule, however, the whole machine is so light that it is easily moved around by hand. A wooden roller may be fitted on the cross brace to facilitate moving the riveter along a center keelson or girder.

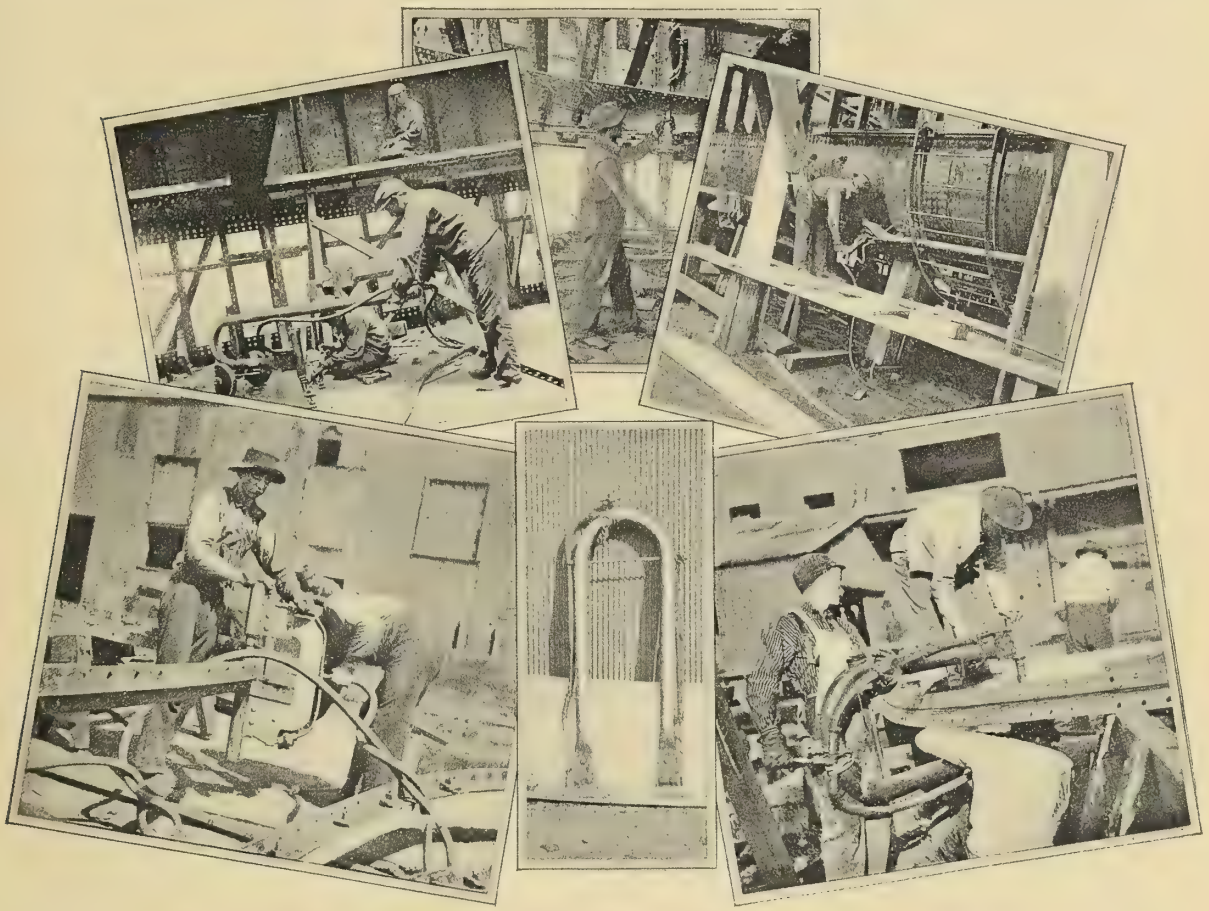
That these machines can and do make better work than hand riveting is evident from several considerations. It is well known that in hand work constant watchfulness is required to make the men properly "plug" the rivet before heading over the point; that is, to strike the first blows exactly in line with the axis of the rivet so as to upset it clear to the head and make it properly fill the holes; it is much easier and quicker

*A paper read at the Sixth General Meeting of the Society of Naval Architects and Marine Engineers.

for the men to knock the head over at once, and when that is done, as the head and point look all right, there is no way of determining in what condition the body of the rivet is, unless it is loose under test, or loosens up in service afterward with the constant vibration and jar of the ship, as often happens. With the machine, however, it is almost impossible not to plug the rivet, the hammer being very easily and naturally brought in line with its axis, and, in fact, will not drive the rivet properly unless it is so in line, and the blows of the hammer being so rapid that the plugging is accomplished before the point is formed. The whole operation of driving the rivet is completed much more quickly than by hand, and before the rivet has lost its heat, the resulting contraction afterward drawing

where a rivet comes in the bosom of an angle or channel, are of this type, and are among those most important to be well driven, the integrity of the framework depending largely upon them. From the nature of the case, hand-driven rivets in such situations are not what they should be, but it is evident that such considerations do not affect the machine in the slightest degree, and that if the hammer can get on to the rivet at all it will drive it as well in such locations as in the most open parts of the work.

Passing now to the case of a rivet so located in the ship that it is not possible to get at both sides of it by a bow frame, we must distinguish at once between those that are finished with a full or button-head point, as in bulkheads, and those with a counter-sunk flush point,



WORK PERFORMED BY PORTABLE PNEUMATIC RIVETERS AT SOUTH CHICAGO SHIPYARD.

everything firmly together as the rivet gets cold, and strengthening the joint by the well-known effect of the friction between its parts.

Again, there are very many places in the framework of a ship where there is not sufficient space for swinging a hand hammer in driving a rivet, or where the rivet can be gotten at from only one side. Such rivets as those through beam knees and frames, in the connections of floors to center keelsons, wash plates between floors, frame brackets at tank tops and decks, in cellular tanks, and generally wherever the available space is only that of the frame spacing, or less, or

as in decks, tank tops, and the outside shell. For decks and tank tops, where the rivets are put up from below and the action of the hammer is always vertically downward, a simple arrangement of the hammer mounted on a bent pipe as if on a wheelbarrow with one or two wheels is all that is necessary. The operator raises the handle end sufficiently to get the die over the point of the rivet and then bears down as the air is turned on, the bend of the pipe being loaded with lead. A second man with a chipping hammer cuts off the surplus metal, and a few seconds' work of the riveter again suffices to complete a very satisfactory

operation. A pneumatic holder-on is used below, and three men and a heater boy will drive from 800 to 1,000 rivets in a day.

In the case of bulkhead rivets, it is evident that the combined hammer and holder-on can be fastened to the end of a beam which slides loosely on a central supporting stud bolted to the bulkhead, with an adjustable stud bolt on the other end of the beam governing the distance of the hammer die from the rivet point, and reaching a good many rivets at one setting. The pneumatic holder-on may be similarly mounted on the other side of the bulkhead.

The die is cupped out, and it is evident that after the first stroke of the hammer the die will be firmly held in position by the metal, which is forced into the hollow of the die. The holder-on is similarly kept central with the rivet by its hollow-ended die going over the head. The resulting finished rivet is all that can be desired.

In the case of flush-pointed rivets, however, a very different arrangement is required. It is evident that, as in handwork, the varying thicknesses of plating, liners, butt straps, frame flanges, etc., and amount of countersink in the plate, make it impossible to so gauge the length of the rivet under the head that, when beaten down, it will exactly fill the countersink and finish flush with the surface of the plate. The only practicable method of driving is to follow as closely as possible the hand method, beating the rivet down with the surplus metal crowded off to one side, chipping this surplus metal off by a cold chisel, either by hand or by an ordinary pneumatic chipping hammer, and then properly finishing the point.

To do this it is necessary that some freedom of movement be given to the hammer—that is, it must be possible to incline the axis of the hammer to a slight angle with the axis of the rivet in any direction, in order that the surplus metal in the point may be properly crowded off to one side to make easy chipping, and also that the point may be properly finished, and, if necessary, slightly rounded, and any seams around the point between the rivet and the plate properly driven together and made watertight.

Three methods may be used for fastening the hammer to the beam: First, the hammer may be mounted in gimbals; second, the hammer may be so mounted in a frame that while the die is held in position against the rivet, the lower end may be given a rotary movement; this is not as good as the gimbals; third, the hammer may be mounted on trunnions, and the beam carrying it turned on its own axis and moved forward and back longitudinally. The third method does not seem very practicable, and we have never tried it.

There is still another method by which countersunk flush rivets may be driven by hammers. In this, the hammer is fastened immovably to the end of the beam, as in the bulkhead riveter, and the flat-faced die has a central hole about 3-16 in. dia. drilled in it. When the rivet is beaten down some of the hot metal enters the hole and the result is a projecting teat on the rivet point, the remainder of the surplus metal flattening out equally on all sides.

This surplus metal is removed by a face milling tool, also made with a central hole, which fits over the teat and holds the tool in position. The milling tool is driven by a pneumatic drill, and after the point of the rivet is milled down flush with the plate the teat is easily cut off by a blow of a hand hammer on a cold chisel. The rivet, however, is not finished in quite as "ship-shape" a manner as by the other method, and we have had so much difficulty in getting a milling tool of the right shape to cut properly that we have abandoned it.

In the Chicago yard, therefore, the only method now used is the first one cited above, which has proved most satisfactory in every way, both on new construction and in the dry dock on repair work. The construction and mounting of the hammer in the gimbals on the end of the pipe beam gives it the necessary swinging motion, as well as a certain amount of motion bodily sideways in any direction without moving the beam. For bottom rivets the beam is hung by a bolt through its center, on which it rotates, to a trolley running inside of a slotted pipe which is bolted to the bottom of the ship, enabling the operator to reach many rivets at one setting. In a variation of the same arrangement, instead of bolting the slotted pipe to the ship, it is held firmly up against the bottom by the simple pneumatic jacks at each end. This avoids missing any bolt holes and is well suited to work in the dry dock.

For the side of the ship the mounting we have so far found most satisfactory is provided with a short vertical beam carrying the hammer and provided at its lower end with an adjustable bolt to govern the distance of the hammer from the rivet. This beam is fastened to a bored-out tee which slides freely on the horizontal pipe. This pipe is counterweighted and hung from pulleys above inside of flat iron guides bolted to the ship's side. The resulting free vertical and horizontal movement of the hammer enables a large portion of the side to be covered without shifting the rig.

For the bilges, which for a large portion of the length of our lake ships are circular, the hammer beam is again a horizontal pipe fastened to a double frame which fits the bilge and travels fore and aft on trolleys above and below.

It will be understood that for all these shell rivets the method is to beat down the head to fill the countersink, chip off the surplus metal, as in hand riveting, by a chipping hammer, and then finish by the machine. In all these methods of mounting, after the rivet is plugged and the head is beaten down, the hammer is easily swung out of the way to enable the chipping to be done.

In all cases the pneumatic holder-on is used against the head of the rivet inside. For the bottom and bilges, the tank top lends itself with facility as a support against which the holder-on can be braced by means of the pipe extension referred to above. In a single ship bottom little difficulty is experienced in adjusting a short piece of plank as a brace by means of hook bolts taking hold of the reverse bars. For the side rivets we have found a simple method to be the use of two pieces of 6 in. by 6 in. scantling extending from the tank to the deck above or from deck to deck, easily bolted in position about 8 ft. apart, with a hori-

zontal piece of 2 in. plank sliding freely on their outboard sides. The plank forms the brace for the holder-on, and is counterweighted and easily moved up and down in unison with the horizontal pipe carrying the hammer outside.

As for the quality of the work done by these various methods of power riveting, I can say that the unanimous opinion of the hull inspectors who have been on duty in our yard for two years and more is that the rivets are first class in every respect, and make far better and tighter work than those driven by hand.

As for the cost, I will say that, adding cost of air, repairs, etc., the saving is from 1 to 2 cents per rivet over piece-work prices for hand riveting, depending upon the location in the ship and averaging about 1 1-4 cents. In an ordinary lake steamer of 4,000 tons the saving is from four to five thousand dollars over hand work.

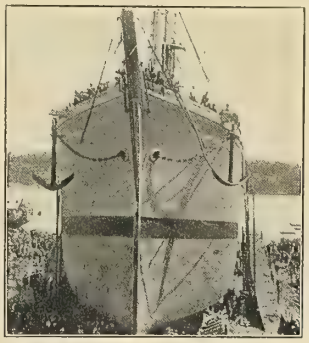
A further and very important advantage, however, is in the fact that skilled labor in one of the principal departments in a shipyard, which has hitherto been indispensable and correspondingly arrogant and high handed, can be replaced by unskilled labor.

In conclusion, I want to say that the quality of the work done by portable pneumatic riveters in ship building is such that the various classification societies cannot ignore it, and before very long will doubtless recommend, if not require, that all rivets in at least the principal portions of the ship be driven by power.

A trial trip of the S.S. La Grande Duchesse recently made to determine the efficiency of her new cylindrical boilers gave very satisfactory results. The coal consumption per I. H. P. per hour averaged about 1.535 lb., which included all coal used for the main engines and auxiliaries, the indicated horse power being that of the main engines only. This ship is now fitted with four main boilers and one donkey boiler, all of the Scotch type. All the boilers are constructed for a working steam pressure of 210 lb. per square inch. The main boilers consist of two double-ended boilers, 15 ft. 3 in. mean dia. by 20 ft. 0 in. long, and two single-ended boilers 15 ft. 3 in. mean dia. by 10 ft. 3 in. long. Each front is fitted with four Fox corrugated furnaces 38 3-4 in. inside dia., each furnace being fitted with a separate combustion chamber. There is a total of 17,100 sq. ft. of heating surface in the main boilers and 410 sq. ft. of grate area, the grates being 5 ft. 3 in. long. The main boilers are fitted with the Ellis & Eaves system of induced draft, with vertical 2 3-4 in. dia. heater tubes in the uptakes in front of the boilers. The products of combustion pass through the tubes, and the air is drawn in around the tubes, and after being heated, conducted to the ash pits through ducts running down the front of the boilers, at the sides and between the uptakes. The induced draft is furnished by an installation of three Sturtevant steel plate steam fans, placed under the stack, each having a wheel 8 ft. dia., and fitted to draw from the uptakes and discharge into the stack. The La Grande Duchesse is a twin-screw vessel of 5,000 gross tons. She was built by the Newport News Shipbuilding and Dry Dock Co., which also furnished the new boilers.

STEEL VS. WOOD AS A MATERIAL FOR SAILING SHIPS, WITH DATA OF AMERICAN SHIPS IN SERVICE.

BY WILLIAM A. FAIRBURN.



SHIPENTINE ROANOKE.

About a quarter of a century ago the wooden sailing vessel ceased to be a carrier of any significance in the British trade, but it was not until five years ago that wood was finally abandoned in favor of steel as a material for the construction of sailing ships in our own country. There are, however, only four American iron or steel sailing ships afloat to-day, and only two of them are of American construction. Their particulars follow:

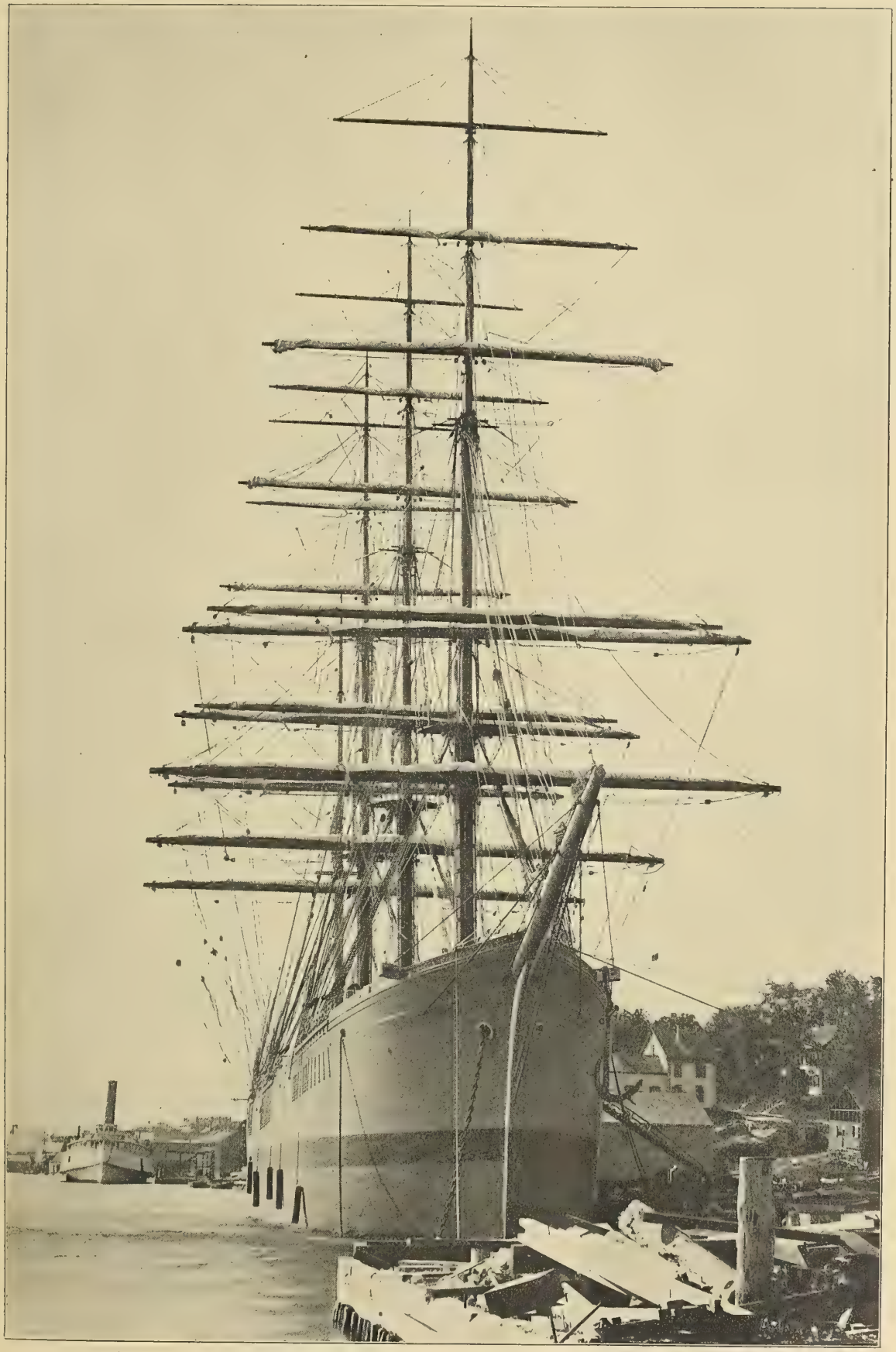
The American four masted ship or shipentine Kenilworth was originally a British vessel, having been built by J. Reid & Co., of Port Glasgow, Scotland, in 1887. A few years ago she was badly damaged by fire in San Francisco. The insurance companies paid a total loss on her and then sold her to Arthur Sewall & Co., of Bath, Me., at a very low figure. After being rebuilt she was granted an American register. Quite recently she put into Valparaiso with a fire in her hold, and her master, Capt. J. G. Baker, the mate and cabin boy suffocated by the fumes and gases from the burning cargo of sugar. The Kenilworth has been an unfortunate vessel. She was well designed and well built, but she cannot be called successful. She is 300 ft. long, 43 ft. beam and 24 ft. deep. The gross tonnage is 2,293 tons and the net 2,179 tons. The main mast truck is 155 ft. above the deck, and the lower yards are 88 ft. long. The masts and bowsprit and the three lower yards on each mast are all of steel, while the smaller spars are of wood. She carries a crew of 35 men.

The four masted ship May Flint is the largest of the American sailing ships. She was formerly the transatlantic passenger and freight steamship Persian Monarch, having been rebuilt at Newport News in 1895. This vessel is 350 ft. long between perpendiculars, 370 ft. over all, 42 ft. 6 in. beam and 36 ft. 3 in. deep to upper or hurricane deck. These proportions are unsuitable for a sailing vessel, and therefore she greatly lacks initial stability. The May Flint is of the usual iron steamship construction, with a cellular double bottom 39 in. deep. Her lower yards are 93 ft. long; the royals are 56 ft. long; the mast from deck to truck measures 159 ft., and she spreads 44,000 sq. ft. of sail. On her maiden voyage she carried 4,320 tons of coal from Baltimore to San Francisco, on a draught of 23 ft. 1 1-2 in. The May Flint has a very small dead weight capacity for so large a vessel, for when light she weighs 2,750 tons. Under certain conditions of lading she would be an unsafe vessel.

The other two American steel ships were built at Bath, Me., at the yard of their owners, Arthur Sewall

NEW STEEL SHIP ERSKINE M. PHELPS—4,500 TONS D. W.

WOODEN SHIP ROANOKE OF BATH, ME.—3,539.03 TONS.



WOODEN SHIP SUSQUEHANNA OF BATH, ME.—2,744.67 TONS.

& Co. They are of the same general dimensions although they differ in model and in various details. The Dirigo is named after the motto of the State of Maine—"I lead"—and she was the first steel sailing ship to be built in America. This vessel was launched February 10, 1894. She is 312 ft. long, 45 ft. beam and 25 ft. 6 in. deep. Her gross tonnage is 3,005 tons and her net tonnage 2,886 tons. The Erskine M. Phelps was completed a few months ago. She is a modified Dirigo, and whereas the latter vessel was built of British steel the Phelps has been constructed throughout with material of domestic manufacture. She is a little finer aft than the Dirigo and is in many respects a much superior vessel to her predecessor.

The Phelps carries 4,500 tons dead weight on 22 ft. 6 in. draught and she stands up without ballast when light in port. This vessel has great stability at light draughts and she is also a stiff boat when loaded with any homogeneous cargo. She has a dead rise of 20 in. with a very easy rounding bilge. She is a moderately fine ship, the coefficient of displacement excluding the keel, being .72. The vessel has a flush main deck of steel fore and aft, the whole of which is sheathed with 3 1-2 in. hard pine planking. The lower deck has steel stringers and tie plates, and it is planked with 3 in. hard pine. A lofty topgallant forecastle with lamp room and store rooms at the sides is fitted forward. There are two steel commodious deck houses, the forward and larger one of which contains comfortable quarters for the crew, also the galley. The smaller deck house aft is fitted up for the accommodation of all the apprentices and petty officers; it also contains the carpenter's shop. There is a large full poop aft, in which is the captain's accommodation, and a nicely furnished saloon 16 ft. square on the starboard side. The mess room and pantry is in the center, while the officers' cabin and two spare staterooms are fitted on the port side, the sail room occupying the space in the lazarette. On top of the poop is a steel chart house which also forms a cabin entrance. The vessel is steered by screw steering gear, the helmsman being protected by a steel hood open on the forward end. A large fore and aft flying bridge is fitted connecting the poop and topgallant forecastle, a great convenience in bad weather. The scantlings of the vessel are equal to Lloyd's highest class, and she has received the highest rating from the American Bureau of Shipping. The Lloyd's numerals are: Transverse No. 96.75; longitudinal No. 29828. Proportions length to breadth, 6.85; length to depth, 10.92. The Phelps has a well proportioned sail plan. The lower masts and topmasts are in one length, measuring 134 ft. The spike bowsprit 67 ft. long; the lower yards 92 ft. long; and the upper and lower topsail yards are all of steel. She carries single topgallant sails, also a royal and a skysail. She has therefore six yards on each of the fore, main and mizzen masts, and being rigged as a shipentine, she carries no yards on the jigger mast. The vessel has four head sails, three main, three mizzen and four jigger stay sails, and with the spanker and spanker topsail she carries thirty-four sails all told, spreading about 12,500 yards of canvas. A donkey engine of 20 horse power works the ship's windlass by means of a messenger chain, and the same motive power is used in port for discharging and taking on cargo. Her three bower anchors collectively weigh 13,400 lb., excluding stock; the two largest ones weigh 4,700 lb. each. She also carries a stream anchor weighing 1,500 lb., and two kedges, one of 750 lb. weight, and the other 400 lb. The equipment of this fine vessel also includes 240 fathom of 2 1-8 in. stud link chain cable, 120 fathom of 4 1-4 in. steel wire and 90 fathom of 4 1-2 in. flexible steel wire tow line, besides the usual hawsers and warps. The crew consists of twenty-four men before the mast, two boatswains, three mates, cook, steward, carpenter, engineer and four boys, thus making a complement of thirty-eight hands all told, including the captain.

Arthur Sewall & Co. are now building their third steel ship, which is the forty-second vessel which has been built by this firm. This ship is now framed and one-half plated, and her construction is therefore well advanced. She will probably be named the Arthur Sewall. This vessel is much larger than the Dirigo and the Erskine M. Phelps, but her model is very similar to that of the latter vessel. The owners are the only builders of sailing ships in the country to-day. They abandoned wood construction after launching the Roanoke in 1892, and they now own a fairly good and well equipped steel shipbuilding plant in Bath, situated on the west bank of the Kennebec, a river that has probably christened more sailing tonnage than any other river in the world.

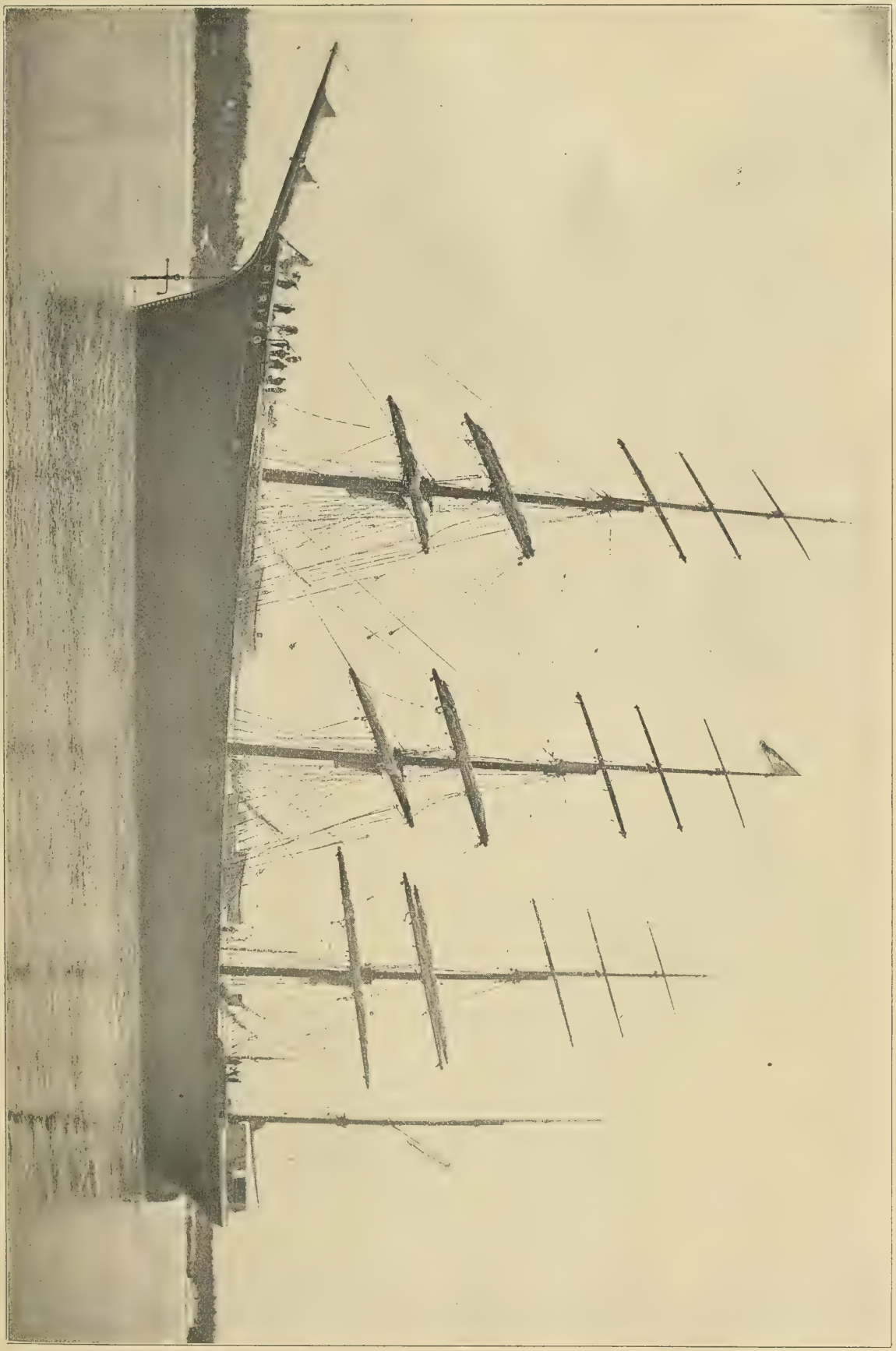
The Roanoke was the last of Sewall's wooden ships, and she is known as the last of the "Big Four," and also as the largest wooden sailing vessel afloat. During the three years preceding the installation of their steel plant A. Sewall & Co. constructed four massive wooden ships, well known as the Rappahannock (burned at sea 1892), Susquehanna, Shenandoah and Roanoke. The last three ships have proved very good vessels, although they cannot successfully compete with modern steel tonnage. The following are their principal dimensions:

	Gross Tonnage.	Net Tonnage.	Length.	Breadth.	Depth.
Roanoke.....	3,539	3,400	311.2	49.2	20.2
Shenandoah.....	3,407	3,258	299.7	49.1	19.9
Susquehanna....	2,745	2,629	273.6	45.1	19.1

The foregoing figures are custom house measurements.

We hear at times even to-day considerable controversy concerning the relative merits of wooden and steel ships. The following figures do not require any explanatory notes, as they state facts which prove the great superiority of steel over wood as a shipbuilding material.

The Shenandoah and the Erskine M. Phelps are two ships both of which have been built to fulfil the same requirements. The Shenandoah is looked upon as the finest and most successful wooden sailing vessel afloat, while the Phelps can be regarded as a fair sample of heavy modern steel ship construction.



SHIP DIRIGO, BUILT AND OWNED BY ARTHUR SEWALL & CO., BATH, ME.—FIRST STEEL SAILING SHIP BUILT IN AMERICA.—G. T. 3,004 TONS.

The Phelps carries a little more deadweight than the Shenandoah, and the weight of her complete hull and fittings is less than 73 per cent of that of the wooden vessel. The Shenandoah's initial cost was a trifle less than that of the Dirigo, but the actual cost of the Roanoke and Dirigo was probably about the same amount, viz., $150,000. A sixty-fourth of the Roanoke was sold for $2,800, and the same amount of the Dirigo was sold for about $3,000 (a high figure), or 7 per cent more, the capacity of these two vessels be-

	Shenandoah.	Phelps.
Launching draft (similar conditions)	10 ft. 9½ in.	7 ft. 1½ in.
Weight of finished hull, % of displacement	35.5	28.5
Deadweight carried per ton reg	1.37	1.56
Deadweight carried per ton weight of finished hull	1.81	2.5

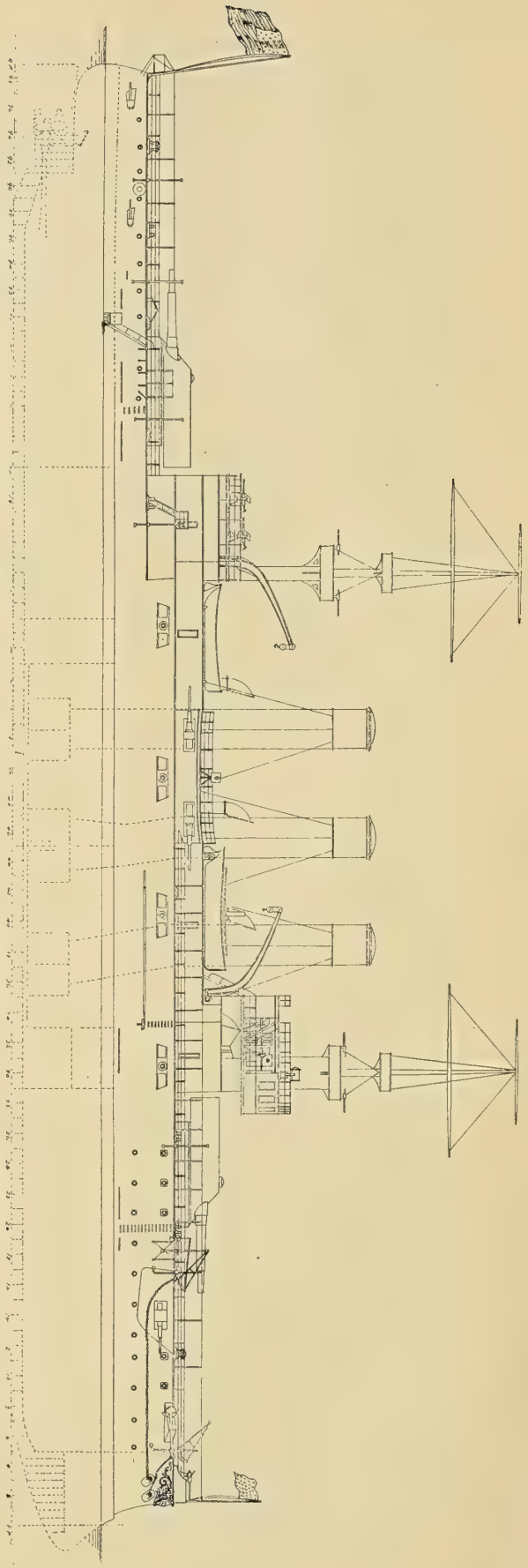
ing about the same. The Phelps has been constructed for a much less figure than the Dirigo, the actual cost of this vessel being quite as low as that of any wooden ship of her size.

The building price of a large wooden ship to-day is about $45 to $50 per ton, and a modern steel ship can be built for about $50 to $55 per ton with a fair profit.

Steel ships not only have a great advantage over wooden vessels in deadweights carried, but they are stronger and stauncher, they last longer, and have a much greater hold capacity on the same outside dimensions.

U. S. Ss. Maine, Missouri and Ohio.

Some time ago we published the general characteristics of the new battleships Maine, Missouri and Ohio, for which contracts were made in October last. In the accompanying drawing a correct profile of these fine vessels is given. Though in general following the lines of the earlier and well known battleships the new vessels will have several readily apparent differences. They are high forward and low aft, and have three smoke pipes ranged in a fore and aft direction. Each turret will contain two high-power 12 in. guns, which, using smokeless powder, will have a muzzle velocity of 3,000 ft. per second. They will also each carry sixteen 6 in. rapid-fire guns and a large number of 6-pounder, 1-pounder and machine guns. One improvement to which Chief Constructor Philip Hichborn, U. S. N., attaches much importance will be the installation of under-water torpedo tubes. Each ship will have two submerged tubes in a single compartment fitted up for the storage of eight 17 ft. torpedoes, and appliances for handling and operating them. Taking the Maine as representative of the type, some of the dimensions and particulars are of special interest: Length, L. W. L., 388 ft.; beam, moulded, 72 ft.; freeboard, forward, 20 ft., aft, 13 ft. 3 in.; mean draught, with 1,000 tons of coal and all stores and ammunition, 23 ft. 10 in.; corresponding displacement, 12,500 tons; speed, 18 knots; and I. H. P., with assisted draft, 16,000.



PROFILE OF THE NEW FIRST-CLASS BATTLESHIPS MAINE, MISSOURI AND OHIO, 12,500 TONS—RECENTLY CONTRACTED FOR.

CONSIDERATION OF THE INDICATOR AND ITS USES ON BOARD SHIP—I.*

BY R. W. JACK.

It is a somewhat difficult task to appreciate the true importance of the application of this device, to the scientific study of the behavior of steam subject to such diverse and varying conditions as we find ruling in its transmission of work. If, however, we approach the subject of steam engine efficiency from its inception with a diligent regard for its history and progress, we can scarcely escape the most certain conviction of the genius of Watt, in the highest sense to which that attribute has been applied.

We are apt to look lightly upon anything with which engineers have been familiar for a hundred years, but if ever a doubt should arise in our minds in regard to Watt's scientific attainments, nothing further need ever be remembered than that it is to him we owe this valuable invention. The development of the steam engine has been as truly a scientific achievement as that to which the progress of any other branch of art has been due. Looking backward, it is really wonderful to find how complete were the theories advanced by this pioneer in the application of steam to mechanics, and how fully their truth has been borne out in modern practice. The steam engine indicator in its primitive form was simply an instrument meant to record the pressure of steam in the cylinder, without regard to the position of the piston. This function alone was then necessary, since at that period the steam was carried the whole length of the stroke, but we are nevertheless indebted to Watt for the diagram of work as represented by an ordinary indicator card, and which he used to prove the economy of working steam expansively. The improvements which have taken place since its first application to a steam cylinder have been merely mechanical.

It is now recognized that the requisite qualifications of a good indicator are, first, a strong spring so adjusted to the extreme limits of pressure to which it is applied, that its greatest compression or tension shall not materially disturb its axis or unduly bend the spring; second, that the moving parts shall be as light and frictionless as is consistent with its work. The most important modifications and improvements have been effected by McNaught, and by Richards, whose apparatus remained for many years the standard, while of late years many beautiful adaptations of the parallel motion and perfected mechanism have combined to render the instrument extremely sensitive, and in careful hands the diagram taken may be considered as nearly approaching accuracy as it is possible such a device can ever attain to. It may be conceded that to offer instructions as to how the necessary precautions and adjustments ought to be made lies rather outside the scope of this essay, and that upon a subject with which we are all more or less familiar, the necessity mainly rests not so much on the practical application of the indicator, as upon the principles which underlie a correct appreciation of its details.

* From a paper read before the Institution of Engineers and Shipbuilders at Hong Kong.

It will be obvious to all that to obtain the correct diagram an indicator should be placed as closely to the cylinder as is possible with convenience in manipulating it. The position and lead of the orifice which connects with the end of the cylinder should be selected so as to prevent any undue influence of the entering or exhausting steam, for it is well known that a jet of steam in blowing across the mouth of an orifice tends to reduce the pressure in its connections. If pipes be used, as they almost invariably are, for convenience in obtaining with a single indicator diagrams from both ends in quick succession, they must be of ample size and well protected by non-conducting material. The motion communicated to the paper cylinder should exactly correspond with the motion of the piston of the engine. In practice this is rarely the case, but the error is generally so small that it approaches sufficiently for most purposes to perfect synchronism. If the motion be taken from the crosshead of the engine, the length of the lever from which the paper barrel receives its partial rotation should be as great as conditions will conveniently permit. It may also be pointed out that in every case the cord or wire should be led at right angles to the lever, when the piston is in mid-position, otherwise the error is aggravated at one end of the stroke and diminished at the other. Those propositions may be easily verified by the aid of a pair of compasses.

Take the first case as represented by Fig. 1. Let *A B* be the stroke of the piston, and *a b* the

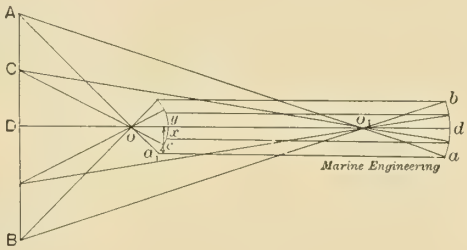


FIG. 1

reduced motion to be communicated to the paper drum of the indicator. Divide *A B* and *a b* into equidistant spaces, say we take 4, then by shifting the position of the fulcrum *o* outward, thereby increasing the length of the lever, it will easily be seen that the error gradually decreases. For instance, take the first fulcrum *o*, the length of the lever is *D o*. From *A* draw Aa_1, then oa_1 will represent the short arm of the lever. When the crosshead (or piston) is in the position indicated by *C*, i. e., one half the distance *A D*, the position on the indicator diagram would be represented by *c*, instead of which it should have been at *x*, which is one-half the distance "*a d*." Referring to Fig. 1 it will be seen that, in the extreme case we have taken with the fulcrum at *o*, toward the ends of the stroke, the motion is almost imperceptible, although at mid-position *D o* both points are moving with the same velocity, consequently unequal relative spaces are passed over in the same time, thereby making the indicator diagram highly erroneous and rendering it completely useless for its intended purpose. If the

crosshead moves from A to C, the distance shown by the diagram will be the vertical distance between a_1 and c, while for the same distance traveled by the crosshead, C D, the length on the diagram will be represented by the vertical distance between c and y. I think it will thus be evident to most engineers that a theoretical curve superimposed upon any diagram which may have been taken regardless of the synchronizing of the paper cylinder with the piston of the engine is necessarily misleading. Again, if we look at Fig. 2, it will be seen that at one end of the stroke the lever and cord are almost in line, and the

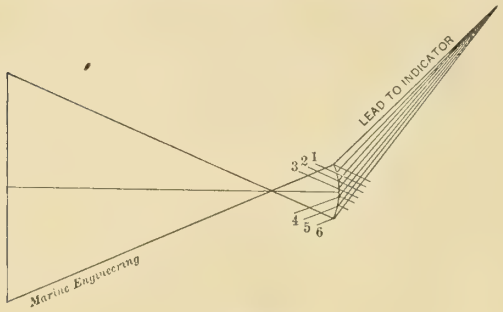


FIG. 2

consequent motion is therefore comparatively slow, while at the opposite end it is at a maximum. Fairly accurate results will be produced with a lever whose length is about 1 1-2 times the stroke of the engine, and if it be worked by a swinging link from the crosshead, the length of such link should not be less than one-third of the stroke. With those proportions the adjustments may be made as in Fig. 3. In any case the connections should be as direct and rigid as the

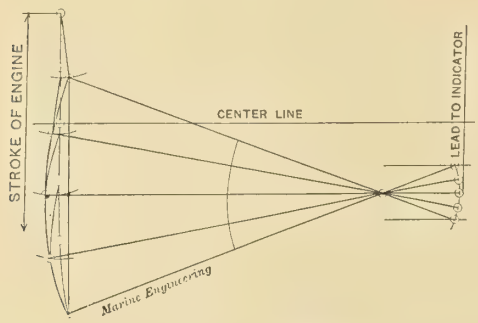


FIG. 3

circumstances will allow, and to this end brass wire may with advantage be substituted for the cord generally used.

An engineer will scarcely require to be told that his best attention is absolutely necessary to every detail connected with the working of the indicator if he would obtain a true diagram and learn what it can teach. Before applying the pencil to the indicator for the purpose of taking a reading the instrument should be tested with the lightest spring of the set. After the various parts have been thoroughly cleaned and oiled, they should be carefully put together, the bracket sleeve carrying the parallel motion is turned until it bears against the stop, and the pencil is adjusted until it just lightly touches the paper drum. Place the paper in position by first folding one edge backward, wrap it tightly around the drum and fold the other edge of the paper back between the clasps. First describe a line on the paper by slightly rotating the paper cylinder by hand; press the piston of the indicator down, and release it very gradually; trace another line; compress the spring by drawing the piston outward, release it slowly and trace again. Those three lines should exactly coincide. It is a test of the whole motion being perfectly free from friction and in good working order. The cord or wire should then be so adjusted that a margin is left at the extremities of the travel to prevent the paper drum from touching the stop at either end. The total length of the diagram is generally about 5 in., and it is supposed that the motion is reduced to give the exact travel. The indicator should be allowed to work for a few seconds before taking off a diagram, in order that it may attain the proper temperature and approximate more closely to the working conditions. It is also advisable that the pipes themselves should be blown through before attaching it.

Diagrams may now be taken from either end in succession and the atmospheric line traced before the paper is withdrawn. We must now trust to our experience and the knowledge we possess to locate any faults, whether they exist in the instrument itself or are attributable to defective adjustment of the machinery. To enable us to read a diagram and to understand and account for the complete figure, it is necessary that we should be familiar with at least the simplest form of valve gear. For this purpose it may be well to state the conditions under which it is most desirable to work a reciprocating engine. Let the piston be supposed at one extremity of the cylinder and under working conditions; steam is admitted and follows the piston at full pressure for a certain part of the stroke. The cylinder is then closed to its source of supply and the enclosed steam expands with diminishing pressure until toward the end of the stroke the cylinder communicates with the exhaust chamber, and this side of the piston remains in this state nearly the whole of the return stroke. At a certain distance from the point whence the piston began, the cylinder is closed to exhaust and the imprisoned steam is compressed by the advancing piston, while still nearer to the extremity of its travel, the cylinder again connects with the source of energy. Those are the points which may be said to be essential to the economical working of the engine, and an indicator diagram will show more or less distinctly each succeeding change and period. Whether it be possible to attain the perfect distribution of steam will primarily depend upon the skill of the designer, and to some extent upon the attention bestowed on the machinery by those in charge. An indicator diagram taken with all necessary precautions must be the final arbiter of the claims of the various valve gears, and so far the oldest and simplest of the surviving valve motions still holds the field. The link motion, as it is called, driven by eccentric pulleys placed on the main shaft, is still the commonest form of device used for communicating the requisite movements to a slide or piston valve, so

that unless otherwise specified it will be understood that it is to it I may apply my remarks.

We are now in possession of the elementary principles which regulate the reciprocating action of a steam engine, and we are prepared to expect an approximate figure to that which theory would suggest. The principal objects of an indicator diagram are, first, that we may be enabled to calculate the power exerted by the engine, from the mean effective pressure shown by the diagram; and second, that we may observe the behavior of the steam upon either side of the piston during each interval of time required to complete one revolution of the engine.

The diagram shown in Fig. 4 will serve to illustrate the method of finding the mean pressure. The length

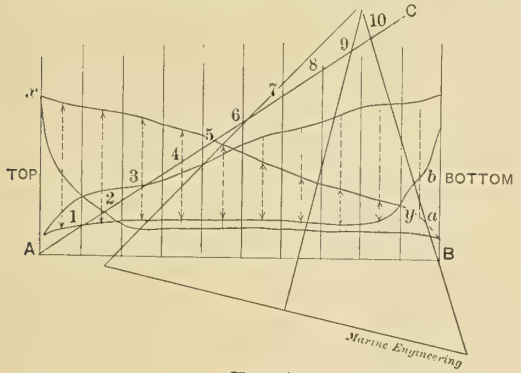


Fig. 4

of the diagrams between perpendiculars raised from the base or line of atmospheric pressure, and touching the extremities of the figures, is first divided into a number of equal spaces. Any number of spaces may be taken, and it will to some extent depend upon the uniformity of the diagram. The greater the number of divisions, the more accurate will be the result. It is generally sufficient in practice and most convenient for calculations to adopt ten. If the figure is very irregular in any division, that particular space may be further subdivided, and the mean taken to represent that space, but such refinements are seldom necessary. Each division is measured midway between the perpendiculars with a scale corresponding to the spring used, the whole added together and divided by ten is the average pressure acting on the side of the piston. The opposite side is treated in the same way and added to the former. This result, divided by two, represents the mean effective pressure on the piston during a complete revolution of the crank. If, however, a set of cards have to be measured by hand it is better to mark off on a strip of paper each consecutive distance, beginning from the one extremity and following on, so that the total length of all the distances is the sum of the pressure by scale. This again divided by ten gives the mean pressure. The usual plan of measuring each diagram separately, though it may approximate the true value, is nevertheless wrong, because pressure alone is not a measure of work. What we really wish to ascertain is the difference of pressures at those intervals existing between the two sides of the piston, so that a diagram from one side should be measured not alone, but with regard to that taken from the other side at the same instant. We should therefore measure from the steam side of the diagram, which we are considering, to the back pressure or exhaust side of the opposite diagram. This will give us the true effective pressure and guide us in a more correct estimate of the varying stresses on the crank pin. In Fig. 4 is shown this method of measurement. The distances between the arrow heads are the true effective pressures, acting either in one direction or the other. On the side marked *Top*, for instance, the effective pressures are all positive from x to y, i. e., the pressure of steam on the top side of the piston exceeds that on the under side at the same instant, until the piston attains the position indicated by y. At this point the pressures balance each other, and the remainder of the stroke is actually performed against a greater pressure acting on the under side, so that we must subtract the distance $a\ b$, or negative pressure, from the aggregate positive pressures.

In the indicator diagram (Fig. 4) is also shown an accurate method of dividing the length of the card $A\ B$ into ten equal divisions. Draw a line at any angle in the direction $A\ C$. With a pair of compasses set to any approximate distance, mark off on the line $A\ C$ ten equal divisions. Join 10 and B, the other extremity of the diagram, and with a pair of triangles divide the line $A\ B$ into the required divisions by shifting the triangles about to suit. If the length of the diagram be fixed in each case, occasion should never arise more than once to subdivide it by geometry, for the correct diagram may be kept for future reference. In most cases the indicator will admit of a diagram being taken 5 in. long, and the gear once set should never be altered, or means taken to ensure the exact position of the pin on the lever, whence the paper drum receive its motion. This length lends itself to an easy division of half inches. In order to facilitate the working out of the mean pressures, a simple and convenient device has long been in use, and is sold either with the indicator or supplied singly. It consists of eleven parallel bars of thin steel, of equal lengths, placed at equal intervals and all connected at the extremities by two parallel frames. An instrument called a planimeter is sometimes used where the taking of diagrams is a frequent occurrence, or for office work. Being a mechanical contrivance it is more accurate and quicker than the geometrical method. The area of the figure as shown by the planimeter is divided by the total length of the diagram, and this, as before, gives us the mean pressure according to scale. From what has been said regarding the correct method of estimating the mean pressure, it will be obvious that two operations by the planimeter become necessary. Fig. 5, first, to ascertain the area of the larger figure a, b, c, d, e, f; and second, to find the area of the smaller figure c, g, h. The latter should then be subtracted from the former and the difference divided by the total length of the diagram as before. This again multiplied by the scale corresponding to the spring in use gives the mean pressure acting on the top side of the piston. The mean pressure acting on the under side of the piston is found in the same manner, added to the former and divided by two. The quotient

should be the exact effective mean pressure on the piston during a complete revolution of the crank.

Having obtained the mean pressure by any one of those methods, we may with the information thus supplied by the indicator calculate the power exerted by the engine. Work may be defined as the product of pressure and space, and power as the product of work and time. The British unit of work is a weight of 1 lb. raised vertically through a space of 1 ft., and the unit of power, as decided by Watt, and called a

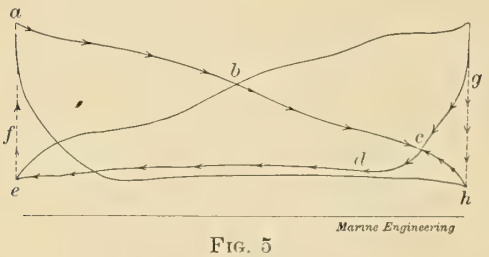


FIG. 5

horse power, is 33,000 foot-pounds exerted for a minute. To calculate the power of an engine we must therefore be provided with certain measurements. We know the mean effective pressure per square inch of piston surface, and to find the total effective pressure we must ascertain the total number of square inches or the area of the piston. The area of a piston is equal to $d^2 \times .7854$ or $(\frac{d}{2})^2 \times 3.1416$. The latter way is the quicker if worked by common fractions, for 3.1416 is approximately 3 1-7. Find the space through which this force acts during one minute by multiplying the length of the stroke in feet by 2 and by the number of revolutions per minute. This is the total travel of the piston in the given time.

The indicated horse power is therefore $= (d^2 \times .7854 \times l \times 2 \times r \times p) \div 33{,}000$ where—

d = diameter of cylinder in inches; l = length of stroke in feet; r = revolutions per minute; p = mean pressure as found from diagram in pounds per square inch.

To save time in calculating the power from a number of diagrams, taken under different conditions, constants may be obtained by working out all the known quantities and thereafter completing the operations with the numbers which are variable. For instance, in the equation I. H. P. $= (d^2 \times .7854 \times l \times 2 \times r \times p) \div 33{,}000$, the quantity $(d^2 \times .7854 \times 2 \times l) \div 33{,}000$ never changes, so that if this be already worked out, it only remains to be multiplied by the mean pressure (p) found from the indicator diagram and by the revolutions (r) per minute. The equation therefore becomes, I. H. P. $= c \times p \times r$ where c is the constant so obtained. Or by having the formula worked out for a range of revolutions between which it is usual to work the engines we may obtain constants for every approximate condition of speed. If we know that the engines are running between the limits of, say, 60 to 70 revolutions per minute, constants may be calculated for every half revolution, and when working out the power of an engine between those speeds it will only be necessary to select the one nearest to that which corresponds with the speed of the engine when the diagram was taken. The general expression for the constant c in this case is therefore $(d^2 \times .7854 \times l \times 2 \times r) \div 33{,}000$, and the power is obtained by multiplying the result by the mean pressure, thus, I. H. P. $= c \times p$.

It is common in calculating the power of an engine to neglect the decrease of the effective area of the cylinder caused by the piston rod. In cylinders of large diameter the practice will not, of course, seriously affect the result, but there can be no valid excuse in any case for such a practice. In the case of triple and quadruple expansion engines where the piston rods are all of one diameter, this consideration of the cross section of the rods becomes imperative. The power of an engine will vary exactly as the area of the cylinder when all other conditions are fixed, i. e., if the length of stroke, number of revolutions per minute, and mean pressure are to be certain quantities, then the I. H. P. will be decided by the effective area of the cylinder. It is thus easy to understand that the error will be the more aggravated when the area of the cylinder is small compared with the cross section of the piston rod. For example, take the case of a quadruple expansion engine whose H. P. cylinder is 21 in. dia., and with a piston rod 7 in. dia. The difference in the two methods of calculation is therefore

$$\frac{\text{area of piston rod}}{\text{area of cylinder}} \times 100 = \frac{38.5}{346.5} \times 100 = 11.1\%.$$

It may be observed that those calculations are useful only so far as they represent the total work applied to the piston, and give no idea of how it is distributed —in friction internal and external, the working of pumps, valves, etc., and the useful or propulsive effect. To obtain such valuable information, though highly desirable, is rather beyond the scope of this paper, and at the best it might, in the absence of reliable experiment, prove only a very rough guess. But there are other lessons to be learned from the indicator diagram. Although the diagram itself is merely an indication of pressures existing at each interval of the stroke, the essential properties of steam are so fixed and interdependent that we may calculate equally well quantities, densities, or temperatures. It is a highly interesting study to estimate the equivalent weight of steam at certain critical points of the diagram, and thus to observe the alternating nature of the conditions to which it is subjected. Steam in the act of expanding does not follow the simple law of a permanent gas, and its behavior has occupied the attention of the most eminent scientists. What is called "Boyle's Law," or the "Law of Mariotte," has been admitted, and is now established as pertaining only to a perfect gas. Stated simply, it is that the density or pressure of a gas multiplied by its volume never changes, that is to say, suppose we have a cubic foot of gas at a pressure equal to that of one atmosphere, then no matter whether that gas be expanded or compressed, the product of its volume into the pressure which it supports is strictly a constant quantity. If it be compressed to one-half of its original volume, the pressure or density is doubled; if expanded to twice its volume the pressure or density is one-half of the original. Another and shorter way of expressing the same law is to say that the pressure of a permanent gas varies inversely as its volume.

It therefore becomes a simple matter to plot out a curve which shall conform to those conditions. To those who are familiar with geometry the hyperbolic curve at once suggests itself as a perfect solution, and the mathematical location of any point in the curve is so easy that any one who understands the rudiments of arithmetic is able to perform the necessary computations. For instance, consider Fig. 6. Let *A B* represent a certain volume, say the volume of a cylin-

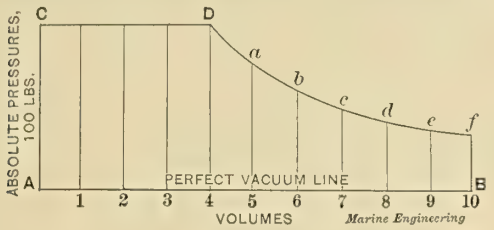


FIG. 6

der in cubic feet (diameter of cylinder in feet squared × .7854 × length of stroke in feet), and *A C* the pressure of steam. Divide the volume *A B* into ten equal divisions, 1, 2, 3, etc. Suppose each division to represent 1 cu. ft. and the pressure of steam *A C* to be 100 lb. per square inch. Let *P* stand for pressures in pounds per square inch and *V* for volumes in cubic feet. We will cut off steam say at *D*, = 4 cu. ft. Now, to find the points on the expansion curve we have only to remember that $P \times V$, or shortly $P\ V$ is a constant, so that to estimate the pressures corresponding to the volumes 5, 6, 7, 8, 9 and 10, we have simply to divide *P V* (i. e., the pressure and volumes before the steam begins to expand) by those numbers representing actual volumes. *P V* is therefore $= 100 \times 4 = 400$. To find the pressures related to the volumes 5, 6, 7, 8, 9, 10, we only require to divide 400 by 5, and by 6, 7, 8, 9, and 10, and mark off the points on perpendiculars raised from the base *A B* to the same scale as that to which the initial pressure *A C* is drawn. Those points we will name *a, b, c, d, e, f*. A curve drawn through those points is therefore the curve of ideal expansion, otherwise a hyperbola. I have said that saturated steam does not exactly follow this law, but only approximately so. The difference is so little, however, that it is usual to compare the actual diagram with this theoretical figure, and it will be readily understood, when we reflect that before steam may be transformed to water it must part with its latent heat, that under the most favorable conditions the two curves will almost coincide. It will now be seen that if the expansion curve on an indicator diagram were a hyperbola, any number of points would give the same result, because in that case the density or relative weight of the steam varies directly as the pressure and inversely as the volume, so that the equivalent weight of water represented by the steam at any pressure and volume would be constant.

A new 165 ft. yacht for J. H. Ladew, of New York, building at the Crescent Shipyard of Lewis Nixon, at Elizabethport, N. J., is of special interest in that her design is such that she can be readily converted into an auxiliary war vessel. Her hull is modeled on the same lines as those of the Coast Survey steamer Pathfinder, recently launched at this yard.

U. S. S. STRINGHAM, TORPEDO-BOAT DESTROYER UNDER CONSTRUCTION AT WILMINGTON, DEL.

Work is well advanced on the torpedo-boat destroyer Stringham, under construction at the yard of Harlan & Hollingsworth, Wilmington, Del. This boat, it will be recollected, is one of three for which contracts were let by the Navy Departmen in July, 1897. The other two boats are the Bailey and the Goldsborough. Our engravings show the condition of the vessel, which has been all plated, and the installation of the machinery is now going forward.

The general dimensions of this vessel are:

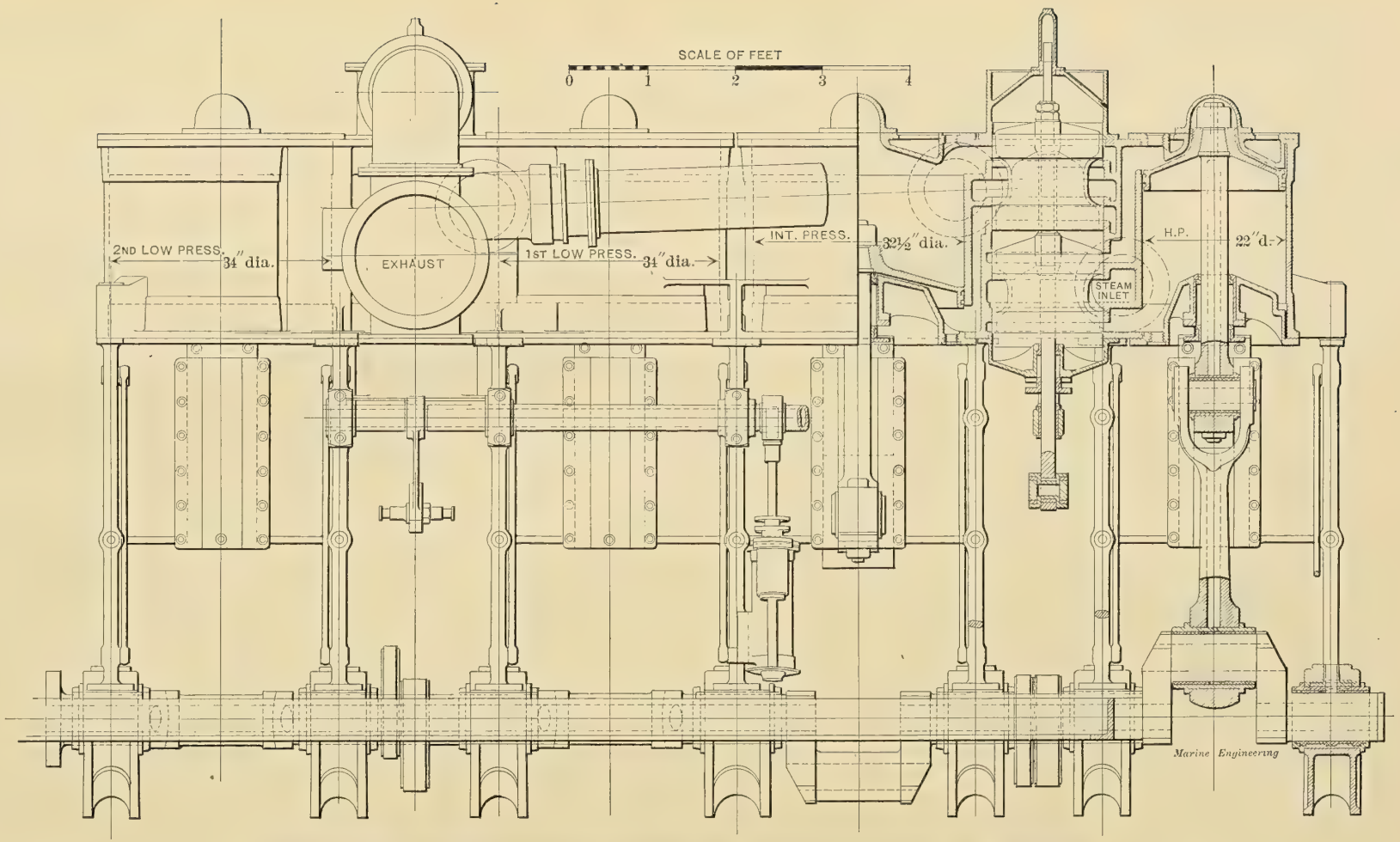
Length over all	231 ft. 4 in.
Length on normal load water line	225 ft. 0 in.
Beam, normal load water line	21 ft. 3 in.
Beam moulded	22 ft. 0 in.
Depth moulded at side	15 ft. 0 in.

Her guaranteed speed on two hours' trial is 30 knots, with trial load of 60 tons and with a displacement of 340 tons. Both her outlines and the general arrangement are shown in the drawings on page 24.

She is fitted throughout with transverse and water tight bulkheads and water tight doors. Williamson Bros. steering gears are operated both by hand and steam from the forward and after conning towers. There is also hand and steam steering gear on the bridge abaft the forward conning tower, and an emergency tiller fitted to the rudder head above main deck. There is also a Hyde steam capstan windlass for wire cable.

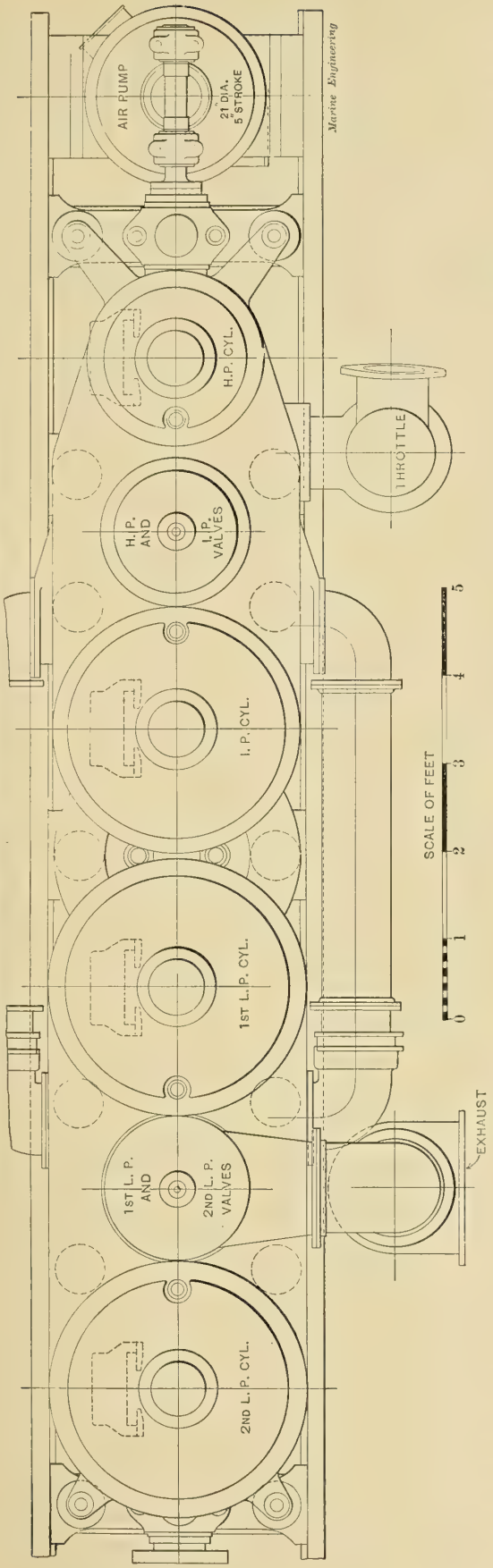
The Stringham will be armed with two torpedo tubes, one placed about amidships and the other aft; both being located so as to bear on either side, and the latter also astern. She has also seven 6-pounder machine guns, so placed that six of the seven can be brought to bear on either side simultaneously, and have a range of about 140 deg. Five of these guns are mounted on the main deck and one each on the two conning towers. As an additional protection to the conning tower, there is an armored turtle back extending from the forward conning tower to the stem, and this is supplemented by a fixed gun shield extending from the turtle back deck aft about 14 ft. on each side of the forward conning tower, about 3 1-2 ft. high, affording great protection against rapid fire guns and small arms. As the Stringham's 6-pounders are machine guns and capable of firing many shots a minute, it will be seen that her broadside is formidable for a ship of her size.

A novel feature of design in this boat of interest to engineers is the arrangement of steam valves in the main engines, as can be readily seen in the accompanying scale drawing on page 22. The propelling engines are alike, right and left, and stand side by side in one compartment. They are of the vertical, inverted, direct-acting, triple-expansion type, each with a high pressure cylinder 22 in. dia., an intermediate pressure cylinder 32 1-2 in. dia., and two low pressure cylinders 34 in. dia., the stroke of all pistons being 18 in. Stephenson link motion is used, each pair of eccentrics imparting motion to the valves of two cylinders. This is accomplished by placing the piston valves tandem so that in each engine the high pressure



FOUR-CYLINDER TRIPLE-EXPANSION ENGINES OF THE TORPEDO-BOAT DESTROYER "STRINGHAM."

and intermediate pressure valves are worked by one rod, and the same also with the two low pressure cylinders. This, of course, not only does away with the necessity for four eccentric sheaves, additional to those in the design and the necessary rods and links, but also permits a very compact fore and aft arrangement of the engines. The piston rods are fitted with single slipper cross heads working in guides bolted to the turned steel columns. The framing throughout is of vertical forged steel turned columns well stayed with diagonal braces. The engine bed plates consist of steel castings for each bearing fitted between two steel angles of 6 1-2 in. by 4 in. by 3-4 in. material, planed true on the faces, and supported on keelson plates, carefully and strongly worked into the framing of the vessel. The high pressure cylinder is forward and the low pressure cylinders aft in both engines. The



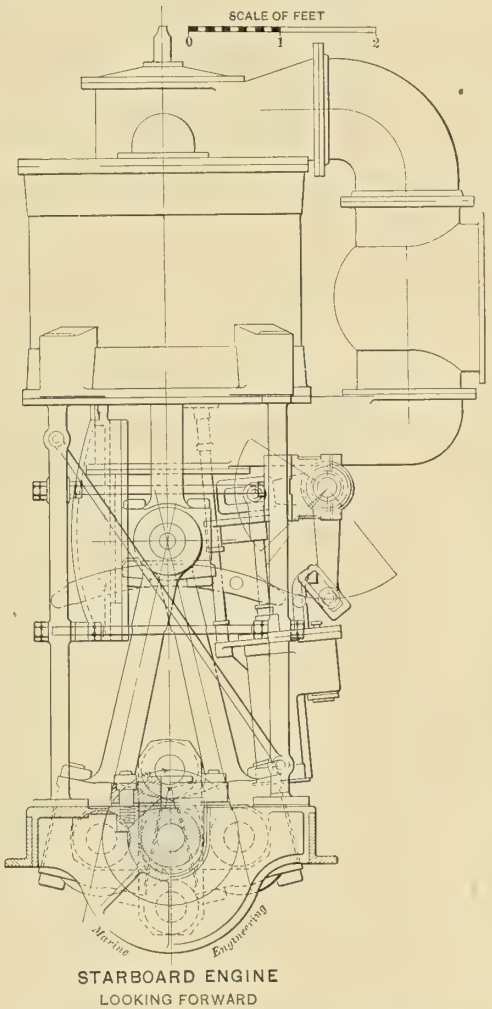
PLAN OF TRIPLE-EXPANSION ENGINES OF THE TORPEDO-BOAT DESTROYER "STRINGHAM."

crank shafts are steel, made in one piece for each engine and are hollow. The shafts, piston rods, connecting rods, and working parts generally, are forged of a high grade of steel. The piston rods and connecting rods are hollow and oil tempered.

The collective indicated horse power is estimated at about 7,200 when the engines are making about 400 revolutions per minute.

The electric lighting plant has a capacity for 100 lights.

There are two condensers, one for each engine, of copper, oval in shape, 12 ft. 9 in. long, containing 1,292 tubes 5-8 in. dia., with a cooling surface of 2,700

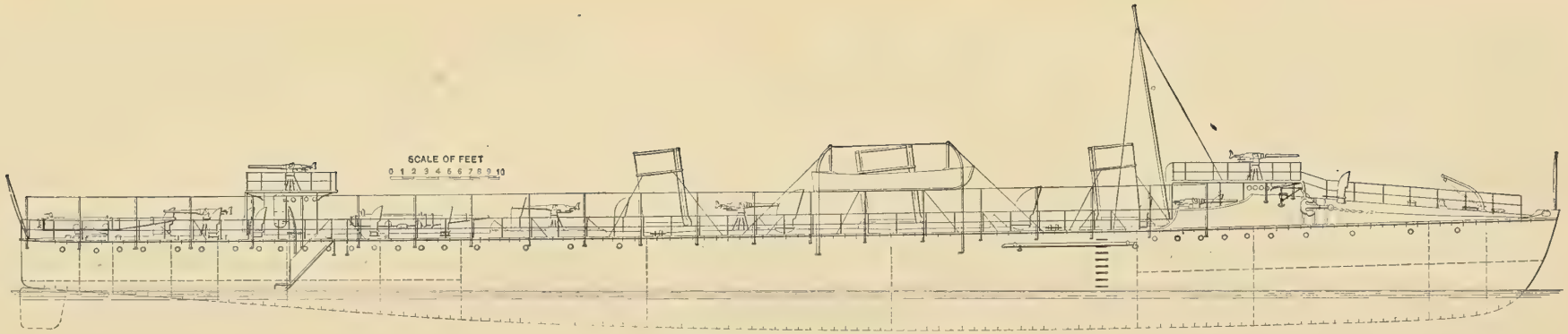


ELEVATION OF "STRINGHAM'S" ENGINES.

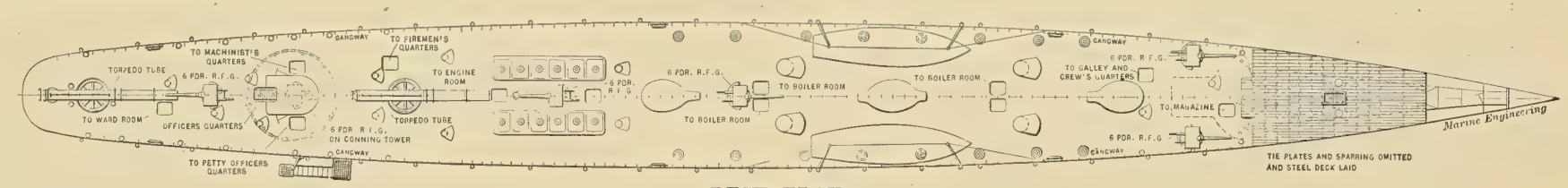
sq. ft. in each. A single acting air pump is fitted for each engine, driven from an extension of the main engine shaft. The circulating of water through the condensers will result from the speed of the vessel.

A small circulating pump driven by a small engine is fitted for slow speed and starting. The propellers are right and left, and are made of manganese bronze. There are four water-tube boilers of the Thornycroft type, with uptakes to three smoke pipes, one each for the forward and after boilers, the other for the two middle boilers.

There are three steam feed pumps in the engine



OUTBOARD PROFILE.



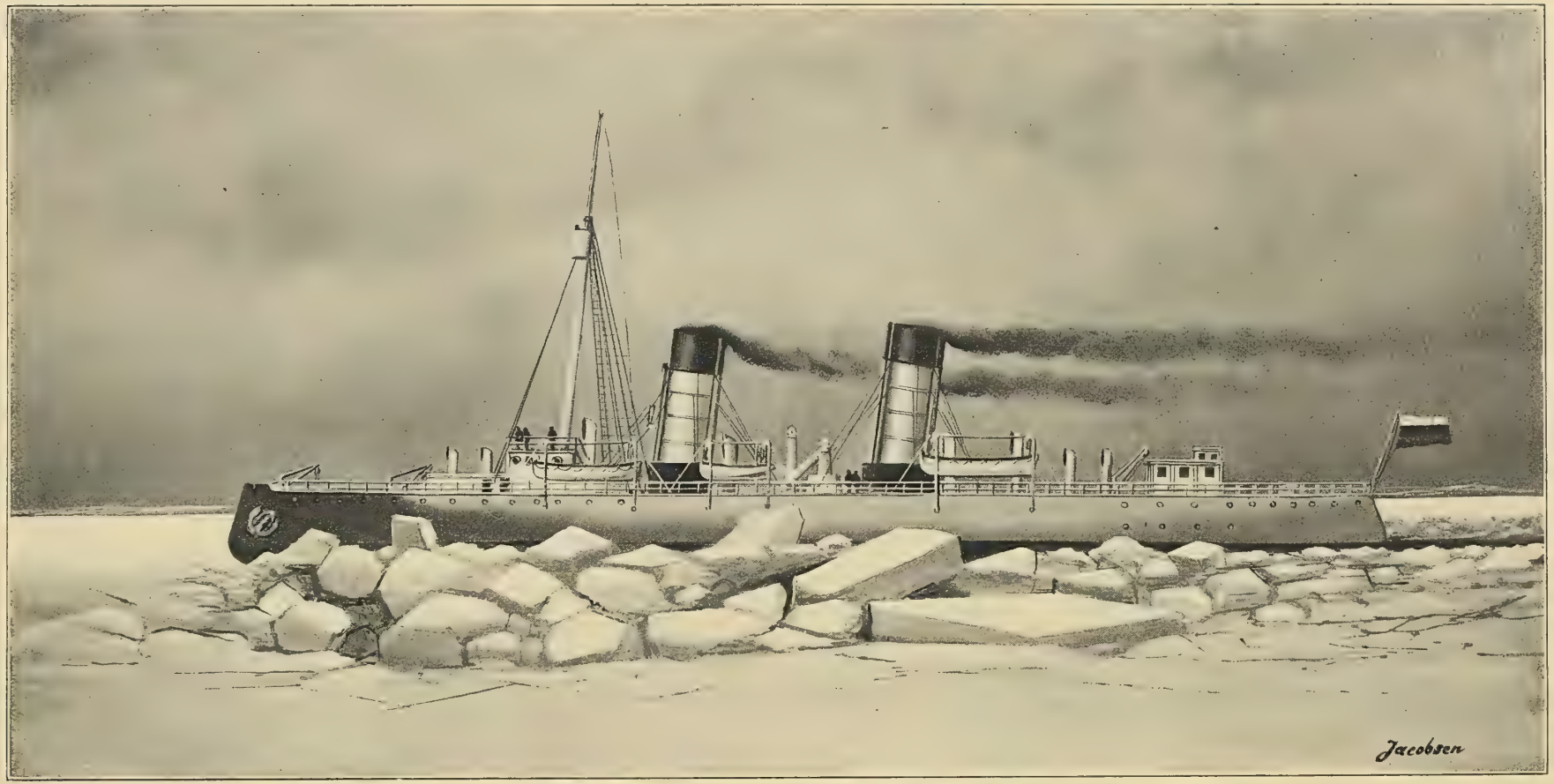
BERTHING ARRANGEMENT AND CABIN PLAN.

PLANS OF THE U. S. TORPEDO-BOAT DESTROYER "STRINGHAM," BUILT AND ENGINED BY HARLAN & HOLLINGSWORTH, WILMINGTON, DEL.

room, any two of which will have capacity enough to feed the boilers at full power. There are also fitted two blowers for the forward fire room and two blowers for the after fire room. An evaporator is fitted capable of making 3,500 gallons of fresh water for boiler use in 24 hours, and a distiller for potable water able to produce 900 gallons per day.

Ample accommodations for officers and crew are provided, with baths for officers and showers for the petty officers and enlisted men.

The complement consists of a commanding officer, two deck officers, two engineer officers, one surgeon, eight line petty officers, eight machinists, fourteen firemen, six cooks and mess attendants, and twenty-one enlisted men in the deck force, or 63 in all.



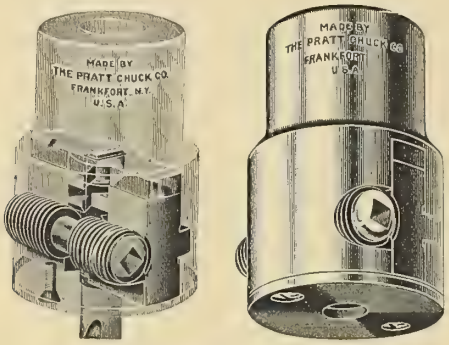
RUSSIAN QUADRUPLE SCREW ICE BREAKER "ERMACK," BUILT IN ENGLAND BY ARMSTRONG, WHITWORTH & CO.

Some time ago a commission composed of Russian shipbuilding experts visited our Lake ports where ice breaking vessels are employed and made a careful examination of the famous Lake ice crushers. Experiences elsewhere were also sought with a view to the design of a powerful vessel for use in opening up channels in various Russian ports during the depth of winter. The practical result was the placing of an order with the English firm of Sir W. G. Armstrong, Whitworth & Co. for the construction of the vessel which our artist has depicted forcing a passage through the solid ice. The new vessel is named the Ermack, and is in dimensions: Length, 350 ft.; beam, 71 ft.; depth, 42 ft. 6 in. She is fitted at the bow and stern with screws driven by four sets of triple-expansion engines of 10,000 I. H. P. in the aggregate. There are six double-ended boilers fitted with Howden draft and a complete equipment of auxiliaries, and extensive electric light plant. The construction throughout has been exceptionally strong, not only in the hull, but in the engines, so that there is but remote danger of disaster from the intended uses of the vessel. The frames are fitted very closely together and there are nearly fifty watertight compartments in all. The Ermack will have a draught of 25 ft. and a corresponding displacement of 8,000 tons.

IMPROVED APPARATUS.

Positive Driving Drill Chuck.

The accompanying cuts are exterior and interior views of the Positive Driving Drill Chuck, made by the Pratt Chuck Company of Frankfort, N. Y. The distinctive feature of the tool is an equalizing driver which takes the flattened shank end of the drill, or



POSITIVE DRIVING DRILL CHUCK.

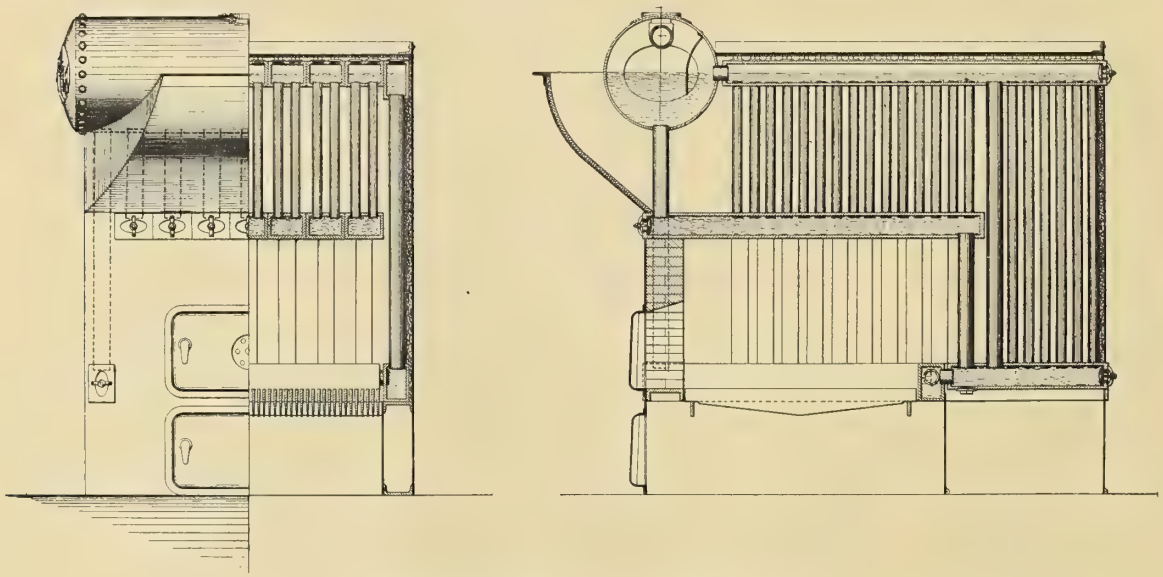
or other tool. This driver consists of a cross bar pierced with a rectangular socket hole, indicated in both figures, lying in the base of the chuck. By the use of this device the jaws of the chuck have only to hold the working tool in perfect alignment, and are wholly relieved of the twisting strain of driving the tool as well. The end of the tool shank need not be accurately or centrally flattened, as the body of the chuck is hollowed out to a sufficiently loose fit about the driver to allow any such imperfect shank to find the socket, and be positively driven by it. The makers claim it is impossible for a tool to slip, and the jaws need be tightened only enough to allow the tool to float—a handy feature when the chuck is in use on worn lathes where the turret holes are out of line. The chucks are made in five sizes.

Hutchinson Water-tube Boiler.

A new marine water-tube sectional boiler, with vertical tubes, is shown in the drawings of a small boiler of this type, which in dimensions is 6 ft. long, 4 1-2 ft. wide, and 6 ft. high, and has about 350 sq. ft. heating surface and 10 1-2 sq. ft. grate surface. The idea in designing this boiler was to create a type in which all tubes should be straight and accessible; which should have a large combustion chamber, a low center of gravity, and an obstructed horizontal path for the products of combustion. The construction is entirely of rectangular manifolds connected together and to a steam and water drum by straight tubes, in all cases secured by expanded joints. All the sections above the grates are exactly similar, making it possible to establish two or three standard side elevations, for different lengths of grate, and to obtain any required H. P. by varying the width of the boiler. The outside sections are extended down so that the water boxes form very desirable edges for the grate and the tubes make good walls for the furnace. It is intended to use for manifolds solid cold drawn rectangular steel tubes about 7-16 in. thick and in no instance larger than 6 in. sq. inside. In the design an unusually large primary combustion chamber is provided and the secondary combustion chamber is eliminated entirely. The address of the patentee is Richard Hutchinson, Tremont Building, Boston, Mass.

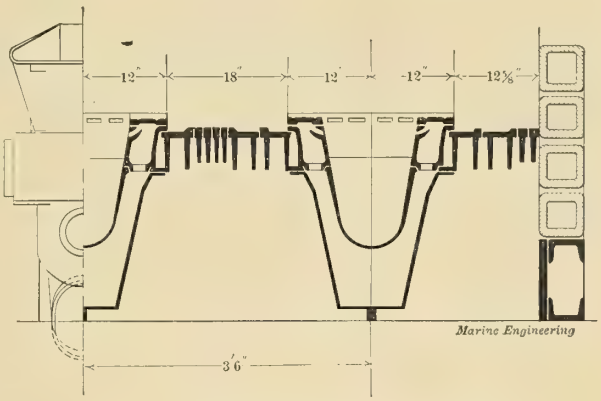
Mechanical Stoker for Marine Work.

To design a mechanical stoker which will be effective when applied to a marine boiler has been the effort of many inventors. In the case of the American Stoker Company this has reached the stage where a practical trial in a large vessel has been decided upon, with the co-operation of the owners. The drawings here published give an idea of the construction of this stoker, which is to be fitted in a new vessel for the Zenith Transit Line, of the Great Lakes, now building at the yard of the Cleveland Shipbuilding



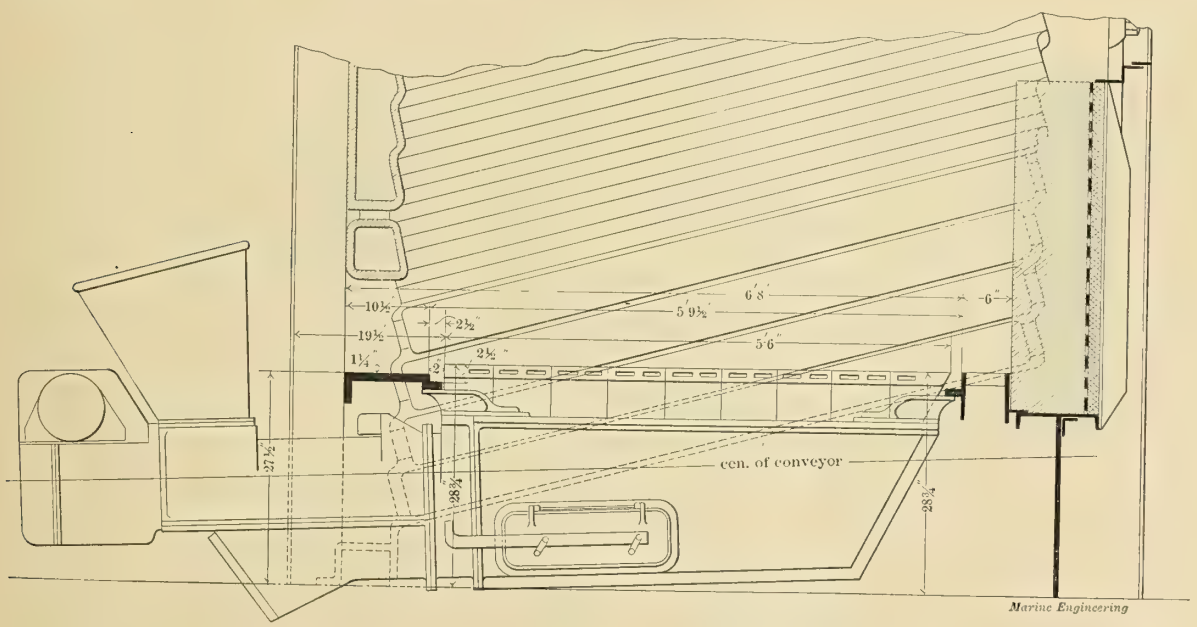
HUTCHINSON MARINE TYPE WATER-TUBE BOILER.

Company. The vessel will be fitted with two water-tube boilers, 12 ft. 5 1-2 in. long and 9 ft. 2 in. wide, fitted in a fore and aft direction with the furnace fronts inboard. The stokers will be used in connection with a system of forced draft supplied by a fan placed aft of the boiler, and connecting with the stokers by ducts under the floor plates. There will be three stokers to each boiler, or six in all, of the size known in land practice as 9 in. Each will be fitted with an independent motor and will have two dead grates. Each group of stokers is designed to burn 1,600 lb. of coal per hour nominally, and 2,100 lb. when forced, and the company guarantees an entire absence of smoke when running. These stokers are simple in design and belong to the underfeeding type. Just in front of the furnace door is a chute which may be fed by hand, as it is in the present case, or mechanically and automatically, as is the case with many installations on shore. In front of this is a small motor which serves to actuate the screw of a conveyor, which carries the coal into the furnace and distributes it up through the guide chamber to the top of the fire, therefore accounting for its name, "underfeed." This screw conveyor or worm extends the entire length of the furnace. Immediately beneath the conveyor pipe is located the wind box. The motor driving the worm has a simple reciprocating motion, having a rod which carries a crosshead, and which, by means of suitable connecting links, operates a rocker arm with a pawl mechanism, that in turn actuates a ratchet wheel attached to the conveyor shaft. The stoker is thus entirely self-contained and complete in itself and consequently there is no danger of the driving and feeding mechanism ever getting out of its correct alignment. At the boilers the coal is fed into the hopper, carried by the conveyor into the magazine or furnace, which it fills, overflows upon both sides, and spreads upon the sides of the grates, as may be understood from the smaller drawing showing the front elevation and section of two stokers of one boiler. The coal is fed slowly and continuously, and approaching the fire in its upward course is slowly roasted and coked, and the gases released from



TWO OF THREE STOKERS FOR ONE BOILER.

it are taken up by the fresh air entering through the passages, which combines these gases, the coal being delivered as coke on the grates. The cleaning of the grates or the removal of the ashes is easily performed and entails no loss, since the coal in its passage has been thoroughly consumed. The boilers will be fitted with furnace doors, and ash pan and doors, so that



MECHANICAL STOKER FITTED TO WATER-TUBE BOILER.

alignment. This of course is an exceedingly important point in an installation, such as that aboard ship, where there is constant motion, tending to disarrange any apparatus the efficiency of which depends upon should the apparatus give out from any cause, hand firing can be used. The address of the manufacturers and patentees, The American Stoker Company, is Broadway and Liberty Street, New York.

MARINE ENGINEERING

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THE event of the month in shipbuilding circles was the launching of the monstrous White Star liner Oceanic at the yard of Harland & Wolff, Belfast, Ireland. In another place in this issue a general description of the new vessel is given, together with reproductions of photographs of the vessel before, during and after the launching, taken expressly for the information of our readers. Aside from mere comparative size, there are many ideas of the owners incorporated in this vessel which are of particular interest. Punctuality, if such a word can be properly used with reference to the schedule arrival of an ocean liner, has been a controlling factor in design rather than record-breaking capacity. In this the White Star line has departed from traditions, just as it did in the past in the matter of form and in interior arrangement of its ships. So accustomed, indeed, had persons interested in such matters become to the rivalry of lines in the matter of speed, that when the vessel was projected the wildest guesses took the form of positive statements—about 27 knots was the limit. But viewing their trade and its possibilities, the owners decided that in their new vessel speed should be subordinated to punctuality, comfort, carrying capacity, safety and commercial success. To be assured of the first a set of dimensions was decided upon, which gave the largest vessel in existence, built or building; a vessel large enough and powerful enough to be able to maintain a high rate of speed in storm as well as calm. Keeping the engine power within limits in such a huge and heavy structure meant freedom from irritating vibrations—therefore comfort. Care in design and honest work in construction provided the factor of safety, and the proportion of machinery and bunker to cargo and passenger space, and the keeping of power within economic limits, assures profitable financial returns. It is certainly a strong argument in favor of those who hold that under existing trade conditions and the present limits of scientific knowledge the end has been reached, if not passed, in liner construction. A moderate increase in speed over existing ships would not have brought the company more popularity among discriminating travelers, though it would undoubtedly for the time attract those (and they are many) who want to travel in the fastest ship. The Oceanic as designed will end her transatlantic trips on Wednesday mornings, thus getting alongside her dock at a seasonable and convenient hour, and, if delayed through fog or otherwise, will have a margin of several hours in which to land her passengers in daylight. Greater hourly speed would mean possibly an arrival Tuesday afternoon or night, in which case the time saved to the passengers on the voyage would be lost in port, especially for those making through connections. To get in Tuesday mornings would mean what is really an enormous increase in speed, with all its attendant cost and discomfort.

RETURNS of British shipbuilding during the year 1898 are recorded in various foreign papers, along with many expressions of congratulation upon the prosperous showing during the year ended and the indications for the year begun. In round numbers the total tonnage launched from private yards in the United Kingdom was 1,600,000 tons, or an increase of about 500,000 tons over the preceding year. At the head of the list in point of total output comes the English east coast yard of Sir W. Gray & Co., with 72,323 tons. The Scotch record was captured by Russell & Co., of Port Glasgow, with 44,551 tons, and in Ireland Harland & Wolff lead with 67,905 tons. Had they launched the Oceanic during 1898 they would have exceeded all British firms, as they did in 1897. The output of all yards outside of the United Kingdom is estimated at about 500,000 tons, so that this gives British yards the credit of putting out three-fourths of the world's shipbuilding during 1898. At the Royal Dockyards naval

vessels of a total of about 71,000 tons were put out, and in private yards vessels built for the British Navy reached a total of about 70,000 tons, the value of all being about $43,450,000. For foreign governments there were launched in 1898 from British yards 52,365 tons of a value of about $17,500,000. This was formerly a class of trade exclusively in British hands, but it is now being cut into by German builders and to some extent by our shipyards.

WE publish an extract from an address by Daniel C. Gilman, LL.D., President of Johns Hopkins University, delivered recently at the opening of the new Library building of Princeton University. The subject chosen by the distinguished speaker was "Books and Politics," and, in his reference to science as contained in the books, he said:

Let me draw from current affairs some illustrations of the highest service that libraries can render to the community in which they are placed. Proceed to the Brooklyn Navy Yard and ask leave to visit a battleship or armored cruiser. Place yourself, if permitted, under the guidance of a naval officer. Listen to his story of how the ship was designed, constructed, protected, armed, equipped, navigated, carried into action and brought out of the terrific fire unscathed and victorious. In the aggregate and the detail you will see the results of applied science more impressive than any of the seven wonders of the world. As illustrations of human power, the Pyramid of Cheops, the Dome of St. Peter's, the great bridges, the continental railways, the Eiffel Tower, take secondary rank when compared with a battleship. Every branch of physical science has contributed to naval architecture. Mathematics, mechanics, electricity, chemistry, metallurgy produced the tremendous enginery of the Oregon, able to ride upon stormy waves and encounter the cyclone unharmed, double Cape Horn without replenishing its coal, discharge its explosives with consummate accuracy, destroy the enemy and protect the lives and limbs of officers and crew. Whence is this applied science derived? From thousands of years of research and record. Mathematics begins with theorems as old as Euclid; steel with the earliest extraction of the ore; the luminous elektron of primeval men was the dawn of electricity; so, in every department, the work of many generations has accumulated. And where is this knowledge stored up? It is perpetuated and augmented in libraries; it is taught in colleges, schools of science and naval academies; by its acquisition "the man behind the gun" is disciplined in accuracy, coolness, memory, ingenuity, judgment and intellectual strength.

This is a worthy tribute, indeed, to the dignity and capability of the constructive and operative branches of our Navy, and it comes, too, with the authority of ripe scholarship and intellectual force. This might well be seriously considered and applied by those who have the future of the American merchant marine within their possibilities of action.

IN the pages of our London contemporary, *The Shipping World,* we note a statement with reference to the shipbuilding year that "the record output for the year goes to an American firm, the Newport News Shipbuilding and Dry Dock Co., having the truly magnificent total of 80,225 tons to their credit." Then are enumerated the battleships Kearsarge, Kentucky and Illinois, the Missouri, the Arkansas and six vessels, each of 5,000 tons. In the interests of truth and statistics we regret to have to say that the "record output" did not go to an American yard. As a matter of fact, the output of the yard named was not anywhere near the figures given. Or does our contemporary mean by "output" vessels in the draughting room or in an uncompleted state on the slips. The battleships Kearsarge, Kentucky and Illinois were launched during 1898, while contracts for the construction of the Missouri and Arkansas were only signed on October 11, 1898. Of the other vessels not one was completed in 1898. If these ships are to be counted in the "output" why not, for example, include the Oceanic in the output of Harland & Wolff? It may be some consolation to our contemporary to know that very probably the statement will hold good a year hence, considering the amount of orders in the yard referred to and the prospects for American shipbuilding.

DELEGATES from the local organizations of the Marine Engineers' Beneficial Association held their twenty-fourth annual convention at Willard's Hotel, Washington, D. C., last month. There was a good attendance and close attention was given to the matters brought up for discussion. Among these was the revision of the constitution, which was so arranged as to enlarge the powers of the branch associations. A clause was also inserted permitting the smaller organizations (having less than fifty members) to join together in sending representatives to the convention. Election of officers resulted in the following being chosen: George Uhler, of Philadelphia, National President; Frank Jones, of San Francisco, National Vice-President; George A. Grubb, of Chicago, National Secretary, and B. Blanchard, of Milwaukee, National Treasurer. Members who will sit on the Advisory Board are: John Steritt, of New York; Joseph Brooks, of Philadelphia, and Joseph Brady, of Baltimore.

EXCERPTS FROM ANNUAL REPORT (1898) OF THE ENGINEER-IN-CHIEF, U. S. N.

Always an interesting document, the Annual Report (1898) of George W. Melville, Engineer-in-Chief of the Navy, recently issued, is of special interest this year. War experiences gave much opportunity for getting a line on the efficiency of various forms of apparatus which had not previously been subjected to war tests. Besides such information the report contains much that is not strictly naval matter, but applicable equally to the merchant marine interests, and is of widespread technical interest. That our readers may have the benefit of this concentration of experiences we publish the following lengthy excerpts:

One very important item of information was obtained from the long and severe services of the ships in tropical waters, and that was the urgent necessity of keeping a large fresh-water supply available for them. The evaporating plants, as usually found sufficient in ordinary cruising, proved inadequate to continuously meet the demands for fresh water there made so unusually heavy and due to conditions imposed by the hot climate. The high temperature of the sea water which is used for condensing the steam from the evaporators reduces the output of these plants to far below the normal, and the serious results from this were shown in salting up of boilers, dropping of furnace crown sheets, and, in some cases, the destruction of boiler tubes. As the very life and efficiency of a steamship lies in the ability to keep her boilers free from heavy scale, it became a matter of greatest moment to send to the fleet ships fitted especially for distilling water in great quantities; vessels that could follow the squadron and supply the daily deficiencies of fresh water wherever they might go.

* * *

Barring the torpedo boats, which will be discussed later in this report, there was a remarkable absence of casualty in the machinery departments of the vessels of the fighting squadrons during the period of the war. Even in action, when forced-draft conditions were in operation, and the excitable natures of the men most wrought upon by the surroundings, the reports show that the machinery not only worked well generally but that in no case was it greatly distressed. This is as fine a commentary upon the personnel as on the machinery.

It is greatly to be regretted that the torpedo boats can not show the same excellent records for their machinery, but it is a sad fact that nearly every one has had some accidents, and the machinery of some at the close of the war was in a condition which can only be described as horrible, where boilers were burnt, cylinder covers broken, pistons and valves stuck, and everything in bad shape. This condition of affairs seems attributable to two causes, the absence of trained engineering supervision and the use of the boats for duty to which they were not adapted.

Before the war the experiment (and it was understood to be an experiment) was attempted of running the torpedo boats with only one trained engineer officer for the whole flotilla, leaving the care of the machinery of the individual boats to young line officers, who had this as a part of their multifarious duties. It is not their fault that they are not trained engineers, and undoubtedly they were faithful in their efforts to perform their duties, but they had not been through the preliminary training which will come with the passage of the personnel bill, and a man without previous training does not become at once a skilled engineer by assuming charge of machinery.

This experience with the torpedo boat is, indeed, an excellent illustration of the benefits to be anticipated from the passage of the personnel bill. Only a very few officers can be carried, but when every one is an engineer by education and training, there is an assurance that these machines will have trained supervision and be kept in good order.

As to the second cause, it did not require this experience to prove that this type of vessel cannot be safely used for dispatch-boat duty and to act as tenders on blockading ships far from the base of supplies or facilities for efficient repair. Primarily, they are intended for high-speed spurts where success or failure in the use of their special weapon shall be quickly demonstrated. For this they are especially built and for this they should be solely kept.

INSPECTION OF MATERIAL.

The material inspected consisted of steel forgings; steel, iron, and brass castings; steel boiler plate, boiler bracing, angles and shapes; lap-welded and seamless steel boiler tubes and steam and water pipe; lap-welded charcoal iron boiler tubes and pipe; brazed and seamless copper and brass pipe and tubes; steel rivets and rivet rods, and finished articles in steel and brass for fittings for engines and boilers; structural steel and plates for the Bureau of Yards and Docks; and anchors for the Bureau of Equipment.

The specifications have been revised to secure the benefit of the progress made in the manufacture of steel, iron, copper, and brass material, the plan now being to write specifications for each class of material to cover the requirements of all classes of vessels, thus avoiding the confusion resulting from the multiplicity of separate books for each kind or lot of vessels. The manufacturers have been consulted about these changes, and the aim has been to write the specifications in such a way that the expense of testing is made as small as possible compatible with the assurance of getting the best material for the purpose intended.

Nickel-steel engine forgings have been brought to a high degree of perfection, and the only regret is that so few companies have undertaken to do this class of work, but the prospect is that in the near future several more steel companies will begin to make them.

Seamless drawn steel boiler tubes have been furnished during the year for all classes of our boilers of a degree of excellence undreamed of a few years ago, and in consequence the lap-welded tube makers have been compelled correspondingly to improve their product, both in material and workmanship.

The securing of a suitable material for steam and feed pipes in the destroyers and torpedo boats became a vital question, owing to the fact that at the temperatures corresponding to the high pressures carried copper and brass, which have hitherto been employed, lose a large percentage of their strength. The difficulty has been overcome by the advent of seamless drawn-steel pipes, with wrought-steel flanges welded on, which are now made with a degree of perfection which makes them absolutely safe.

When it was decided that the new battleships should be practically identical with the Alabama class, and that no hull changes would be made, it became necessary to find a way to reduce the thickness of the shell plates for cylindrical boilers. The shell plates in the Alabama class had reached a thickness of 1 7-16 in. in material having a tensile strength of over 65,000 lb., an elastic limit of over 35,000 lb., and an elongation of 24 per cent in 8 in. for longitudinal specimens.

Experiments have been made on a higher-carbon steel, oil tempered and annealed, which has a tensile strength of over 74,000 lb., an elastic limit of over 40,000 lb., an elongation of over 21 per cent, with a very satisfactory transverse cold-bending test. Such material allowed a slight reduction in thickness from that used in battleships Nos. 7, 8, and 9, although the boilers were designed for the higher pressure called for in the new battleships.

Nickel-steel bracing and rivets have been made and tested and found suitable for use with this high-grade boiler plate, easily reaching the requirements of the Bureau's specifications.

Experiments have also been made with nickel steel to fill the high-grade shell-plate requirements, which gave very satisfactory physical results, with a surface much better than that furnished for the boilers of the Chicago but not as perfect as that of the high-grade carbon steel just described.

WATER-TUBE BOILERS.

In the report of last year attention was called to the increase in the use of water-tube boilers in all foreign navies, and the opinion was expressed that sufficient experience had been gained at home and abroad to warrant us in using boilers of this type in all our ships. The occurrences of the past year have served to strengthen this opinion, and the Bureau, in its recent designs, except for the battleships, has specified this type of boiler.

In view of the fact that the Department's plans for the battleships, for which contracts have just been awarded on the builders' plans, provided for cylindrical boilers, an explanation of this seeming inconsistency is necessary. The Bureau did prepare a design for water-tube boilers, which it was very anxious to use, but it having been decided that the new ships should be practically identical with the Alabama class, and that no hull changes would be permitted, it was impossible to use water-tube boilers, as that would have involved a readjustment of hull weights to maintain the trim.

Notwithstanding this temporary postponement of the Bureau's desire that all of our new ships should have water-tube boilers, the Department's circular of July 26, which encouraged builders to submit designs for higher speeds and

greater endurance, made it almost certain that water-tube boilers would be secured, inasmuch as the easiest way to accomplish the desired results was by their use, and there was little doubt that the builders when given the opportunity, would submit plans for vessels as good as any in foreign navies. The bids which were received on September 1 justified this idea, and although all the bidders did not offer water-tube boilers it is practically certain that they will all install them, so that the Bureau has the satisfaction of knowing that the machinery of these new vessels will be in all respects of the most modern type, as its own specifications would have called for had not the limitations imposed by conditions external to the machinery prevented this desirable consummation.

At the present day it would be hard to find any design for the machinery of new naval vessels which does not include water-tube boilers. The demands upon the engineer for great power on small weight, in order to secure the higher speeds for all classes of vessels which are now common, have practically ruled out the cylindrical boiler on account of its weight and inability to carry the high pressure needed.

The tactical importance of water-tube boilers is also being thoroughly recognized, and has been emphasized by the conditions which obtained in our blockade of Santiago and the great victory of July 3. It was necessary for a long period that our ships should be ready to develop maximum power at a few minutes' notice, and with cylindrical boilers this involved keeping all the boilers under steam, with heavily banked fires and an attendant large consumption of coal. Water-tube boilers of the proper kind, which admit of the rapid raising of steam with safety, remove this difficulty and give the commanding officer a more complete control of his fighting machine.

Without going at length into the other advantages of water-tube boilers, which have been published repeatedly, it may be added that one very striking advantage for war vessels is that the boilers can be replaced or practically rebuilt without disturbing the decks, all parts being small enough to pass through permanent openings. This was the case in the Monterey, as mentioned last year, and it was strikingly illustrated this summer in the case of the Canonicus, Manhattan, and Mahopac, where it would have been impossible to use any but water-tube boilers without practically rebuilding portions of the hull.

It may be remarked in this connection that all of our torpedo boats have water-tube boilers, and that four large vessels, including the Monterey, are so fitted. The Chicago and Atlanta also have boilers of this type now installed. The four new monitors, for which bids will be opened October 1, will have water-tube boilers, and the sixteen destroyers have them as a matter of course.

It thus appears that, as the new battleships to be built on the contractors' plans will also use water-tube boilers, we have definitely taken the step of adopting them for all our vessels, and there can be little doubt that the efficiency of the fleet will be increased in consequence.

In water-tube boilers with straight tubes there has been thus far an unfortunate lack of economy under forced draft, but this will be avoided in the boilers for the new ships by using heaters for the air, which absorb the heat from the gases of combustion before they reach the smoke pipe and thus enable a good economy to be secured.

As was stated in the last report, there is not yet any agreement as to the particular make of water-tube boilers which is best from every point of view. Nearly every one has some feature of excellence, and it can not be doubted that, with the great amount of the best engineering talent which is working at the problem, one or more forms will finally be developed which will be thoroughly satisfactory in every way.

LIQUID FUEL.

When the last report was written, it was anticipated that apparatus for burning fuel oil would have been installed on one of the cruising torpedo boats, and experience have been acquired as to the working of this fuel in regular service. The war of course prevented anything of an experimental nature being attempted on vessels of this class, of which we had so few. It is intended after the resumption of normal peace conditions to carry out the original programme.

Last winter, however, through the cordial co-operation of the Chief of Ordnance, who is always eager to further any effort looking to an increased efficiency of the fleet, the Bureau was given control of the small torpedo boat Stiletto (belonging to the Ordnance Bureau) for several months. The fuel-oil apparatus of the Consolidated Gas Fuel Company, which had given excellent results in tests on a small scale, was installed under the personal direction of P. A. Engineer John C. Leonard, to whose zeal and painstaking work the Bureau adverts with much pleasure.

The object of the experiments was not the determination of economic values, as that side of the question has been so thoroughly investigated as to make further work of the same kind unnecessary, but to give the system a thorough trial under the conditions of regular daily service in order to ascertain its cost, reliability, and general satisfaction.

The tests under Mr. Leonard's personal direction were very satisfactory, and, although the economy was not high relatively to coal (due to the machinery which was not specially adapted to the use of oil fuel), the economy was the same as had been anticipated from previous experience. The personnel of the boat were carefully trained during these tests, and as long as they were under Mr. Leonard's supervision were efficient and seemed enthusiastic about the new fuel.

When the Stiletto returned to Newport the machinery was entirely in the hands of the crew without any engineering supervision, the boat being employed in her ordinary duties as a tender, and the system did not give satisfaction. The commandant of the torpedo station reported that the use of fuel oil was more expensive and less satisfactory than coal, and that the boat was less available and less reliable than when using coal. In view of these statements, and his recommendation that the fuel-oil apparatus be removed, it has been taken out. It would seem, however, that as the apparatus gave satisfaction when under the control of a competent officer, its failure in regular service was not due to any inherent defect, but to indifference or lack of acquaintance on the part of those who handled it. The Bureau does not consider this experience as at all unfavorable to the use of oil fuel, but anticipates that its use on a larger scale, under the direction of a skilled engineer, will prove entirely satisfactory.

There is no difficulty along our eastern coast of procuring a suitable fuel oil in any desired quantity, and representatives of firms handling this oil have repeatedly stated that in considerable quantities it can be furnished at a very moderate price. The small amount needed for the Stiletto at Newport made the price so high (over 7 cents per gallon) as to preclude its general adoption if such figures were to be the rule. The oil used had a specific gravity from 0.85 to 0.87, a flash point of about 315° F., and a burning point of about 350° F. A bunch of burning waste when plunged into it was extinguished. There can therefore be no doubt of its perfect safety for use on board ship.

THE STEAM TURBINE ON SHIPBOARD.

Although the steam turbine itself was not a novelty in engineering, owing to the skill with which its economy has been developed in England by the Hon. C. A. Parsons, its application last year to propulsion on the Turbinia was a decidedly novel step, and the remarkable performance of that little vessel of 42 tons displacement in attaining a speed of over 31 knots attracted the attention of engineers and shipbuilders all over the world. While an analysis of the published data of the performance would seem to indicate that the boiler was the most remarkable part of the machinery rather than the turbine, the fact remains that the combination enabled a phenomenal record to be made.

During the year the Bureau has been carefully investigating the adaptation of the steam turbine to naval uses, has kept informed of the progress of experiment on two forms of turbine being developed in this country, and has been represented at an economy test of one of them.

Thus far the results obtained do not warrant an expectation of the substitution of the turbine for the steam engine in the near future, but the experimental work will be carefully watched so that, should further experience warrant the use of the turbine, the service may be among the first to profit thereby.

REPAIR SHIPS.

In the last report attention was called to the desirability of making such preparation for the fitting out of a vessel which would be a floating repair shop as would enable the work to be done with great rapidity when needed. Immediately on the prospect of war the Bureau again brought this matter to the Department's attention, and the steamer Chatham was bought, set aside for this purpose, and renamed the Vulcan. The work of installing the machine tools, cupola, forges, brass furnaces, etc., was pushed as rapidly as possible, as well as the selection of a force of skilled mechanics. A large and well-chosen outfit of stores of all kinds was also supplied.

The Vulcan arrived at Guantanamo on July 1 and proved of the highest usefulness to the fleet, making repairs of all kinds and furnishing much needed supplies to every department of nearly every vessel. At the end of August

reports from her officers showed that she had made repairs to 63 ships and had supplied stores to 60. Her unusual facilities and the large number of skilled mechanics on board (about 100) enabled her to make repairs of all kinds, including hull work, gun mounts, dynamos, main steam pipes, main piston rods (for small ships), brass castings without end, and iron castings in considerable quantity. This last is specially interesting as the first instance of the successful use of a cupola on shipboard.

DISTILLING SHIPS.

It was evident, as soon as the fleet began to assemble in the Gulf, that some provision must be made for supplying an adequate amount of fresh water for the boilers, as the distilling plant ordinarily supplied is not large enough to furnish all the fresh water needed for personal uses, and also the extra feed consequent upon losses in the machinery, except at very moderate powers.

A multiple-effect evaporating machine, which would be able to give more than 20 lb. of fresh water for each pound of coal burned in the boilers evidently was the most satisfactory solution of the question, as a vessel with such apparatus of 50,000 or 60,000 gal. per diem, and with a coal capacity of, say, 3,000 tons, would be able to supply an amount of water equal to a large number of tank vessels. Such a vessel would also have the further advantage that she is practically a collier at the same time, and should there be an emergency in which coal was needed more than water, her large supply of coal could be utilized for that purpose instead of distilling.

As already stated elsewhere in the report, two vessels were purchased and converted into distilling ships. Unfortunately, the work of constructing the apparatus required so much time that neither was completed before the active operations of the war had closed. The Iris, however, was finished in time to enable her to be sent to Montauk Point to supply fresh water for drinking purposes to the army there.

A distilling ship is, in my opinion, of vital necessity for a fleet of any size, and I believe that we should keep these two vessels in good order at all times, and ready to be sent with a fleet whenever it is likely to operate where it would be difficult or expensive to obtain fresh water. The cost of supplying water with these economical plants is very much less than water can be purchased anywhere, except under the most favorable circumstances, such as at large cities, where vessels can go alongside the dock and take water from the city mains.

While it was of first importance that cylindrical boilers should have fresh feed only, it is absolutely necessary to the integrity of water-tube boilers that they should never use anything else, and this involves an increase in the evaporating plants of ships fitted with these modern boilers, and provision for the storage of an adequate amount of fresh water in the double bottoms or in special tanks. The universal practice of the merchant marine in using the double bottoms for this purpose shows its entire practicability. The distilling ships will furnish this extra water in the most economical way.

THE OREGON'S PERFORMANCE.

It has not been customary to call special attention to the performance of vessels except on trials under maximum conditions, but that of the Oregon is so exceptional that it deserves a record in the Bureau's report. She was ordered from the Pacific to the Gulf before war was declared, and, leaving Puget Sound March 6, arrived at Jupiter Inlet May 24, having steamed over 14,500 miles, stopping only for coal, and not being delayed an hour anywhere through any derangements of the machinery. Stopping at Key West only long enough to coal, she took her place in the blockading fleet at Santiago, and was always ready for service.

This alone would have given her an unparalleled record among battleships, but the culmination came in the great battle of July 3, when she surpassed herself. Always ready for action, she speedily attained a power greater than that developed on the trial, giving a speed (on account of greater displacement and foul bottom) only slightly less than then attained, and distancing all the other ships except the Brooklyn, which is 5 knots faster. Every official report comments on her wonderful speed, and it is generally believed that but for it one at least, and possibly two, of the Spanish ships might have escaped.

The whole record is thus one which has never been equaled in the history of navies, and it will remain the standard for a long time to come. The credit is due, in the first place, to the builders—the Union Iron Works—for the excellence of the material and workmanship, but still more, and chiefly, to the engineer department of the vessel. The Bureau, therefore, takes great pleasure in commending to the Department's more favorable consideration Chief Engineer Robert W. Milligan, the executive head of the department, for his professional ability, untiring care and excellent discipline; and also the junior engineer officers and the enlisted men, whose faithfulness and zeal, under most trying circumstances, have enabled our Navy to add this to the other brilliant records of our vessels.

VOLUNTEER OFFICERS.

The wholly inadequate number of regular officers of the Engineer Corps for the proper performance of duty even in times of peace made it necessary to have recourse to a large number of volunteers when the war brought about such a great increase in the number of vessels. Every regular officer on the active list who could be sent to sea without positive injury to the public interests was so detailed, their places on shore being filled chiefly by retired officers and in some cases by volunteers. It was felt to be of vital importance that our fighting ships should have the regular officers, whose thorough discipline and training would insure maximum results from the machinery, and this policy was systematically followed. In many cases, however, the complements had to be brought up to the proper numbers by volunteers.

In the appointment of these volunteer officers every effort was made to get men who had a thorough mechanical education and, where practicable, sea experience. In the case of the younger men this last was of course usually impossible, but they had usually received a superior technical education and were familiar with machinery. While it can not be claimed that all were of immediate value, the reports received show that, as a rule, they entered upon their duties with great zeal and did everything possible to make themselves useful and efficient officers. A large percentage are splendid types of highly educated and patriotic Americans of whom the country may justly be proud, and who reflect credit upon our great technical schools from which they graduated.

A respectable portion of the volunteers are men of the first rank in mechanical engineering, including a number of ex-officers of the Engineer Corps, who gave their services at a great personal sacrifice. To one of them the success of the repair ship Vulcan is largely due.

The present outlook is for a great increase in the demand for officers at sea, due to the increased number of ships that must be kept in commission to look after our oversea possessions, gained during the war. The number of regular officers will not begin to be adequate for this duty, and even the personnel bill, which was planned for a smaller navy, will not furnish enough officers. I would therefore earnestly recommend that the process of mustering out the volunteers be carried on so as not to reduce the aggregate number of regular and volunteer officers below that necessary for the proper performance of duty.

It is possible, and even probable, that the number of ships which must be kept in commission for some time will be such as to make it absolutely necessary to have more officers than can be furnished under the provisions of the personnel bill for some years.

In that case it may become necessary to arrange for the appointment of some of the volunteers in the regular service. This will be somewhat difficult to arrange without interfering with the personnel bill, whose importance is so great that I would hesitate to make any recommendation that might even seem to conflict. That bill assumes such a training for the young men that they can perform interchangeably duty on deck or in the engine room. This the volunteer engineers can not, of course, do at once. It seems to me possible, however, that by a careful selection of those who are young enough and have shown an aptitude for the service we may secure the necessary numbers for the immediate performance of duty with the machinery and require them, after a reasonable term, to qualify themselves for the additional duties which they will have to perform under the provisions of the personnel bill.

LESSONS FROM THE WAR.

The war which has just ended is the first in which modern steam vessels have had a thorough trial, and it seems pertinent to note the more important lessons which have been taught by our experience. With respect to the machinery they are as follows:

1. The vital necessity of giving the machinery of vessels in reserve frequent tests under working conditions, so that any defects may be discovered and remedied before war makes the vessels' services absolutely necessary. In several cases defects were found after the ships had begun cruising, and the repairs laid them up in the midst of the war.

2. The great importance of having all our naval stations in positions of strategic value properly fitted out for repairs and with adequate supplies of nonperishable stores. It had been evident for a long time that Key West was such a station, but money to put in a proper repair plant was refused year after year, and only granted after the war had begun. The movement of large bodies of troops and their equipment almost blocked the railroads, so that after the beginning of the war it was almost impossible to secure the forwarding of tools and supplies.

3. That fresh water for the boilers is almost as important as coal, and that a distilling ship is an important adjunct of a fleet operating away from a base where fresh water can be readily obtained.

4. That every fleet needs a repair ship to enable the efficiency to be maintained without leaving the station, and consequently that several ships should be equipped so as to be ready to proceed with the fleet.

5. The great tactical advantages of water-tube boilers. This has already been discussed under another head.

6. That if more than two main engines are to be fitted, there should be three engines driving three screws, and not two main engines on each shaft. The New York and Brooklyn had their forward engines disconnected at the time of the Santiago fight, and could not stop to couple them. An accident to any part of either of the two engines on a shaft disables half the power; in the three-screw ship this friction would be only a third.

7. That there should be frequent trials under forced draft to keep the blowers in good condition and to make the men thoroughly familiar with working under maximum conditions. It appears that some of the ships had never been under forced draft since their contract trials until the day of the fight at Santiago.

8. That the location of the forced-draft blowers is a matter of serious importance. In some of our ships, owing to the demands for all other space for other purposes, the blowers had to be located in corners or pockets in the fire rooms, where it was impossible for human beings to give them proper attention, owing to the intense heat due to lack of ventilation. In the Cincinnati temperatures as high as 205° Fahrenheit were noted, and the commanding officer, when investigating the case personally, had his face scorched. The blowers must be placed where they can be properly cared for, or else they are useless, and might as well be left on shore.

9. That the personnel of the service should be adequate to the material. It has been notorious for some time that this is not the case, and we are providing for a decided increase in the number of vessels with no increase whatever in the personnel. By sending nearly every officer on the active list to sea, we were able to give the regular ships a fair complement of trained ones, but had the war been of long duration we should have been greatly embarrassed to supply the places of those disabled or invalided. Volunteers, however well trained in other ways, cannot entirely replace the regular officer.

10. That we must make provision for training the enlisted men of the Engineer Department. Many of the colliers and auxiliary vessels had to start out with absolutely green crews, many of whom, so far from having the "sea habit," had never been on a vessel of any kind. This must be remedied if our enlarged fleet is to be efficient.

11. That our fighting ships must have the highest practicable speed. There is an almost general agreement on this point among naval men, but if any had thought that this did not apply to battleships the fight at Santiago must have shown that the highest practicable speed is just as important in these vessels. It is very gratifying, therefore, that our three new battleships are to have speeds of at least 18 knots, which is now recognized as the standard.

Receivers have been appointed for the Atlantic Transportation Co., which not long ago chartered a number of steamers and barges on the Great Lakes of the capacity of nearly 70,000 net tons, for the purpose of using them in the Atlantic coast trade, carrying coal chiefly. A complete list of these vessels and their owners was published in our November, 1898, issue. Since the charters were written it is stated the company has lost large sums of money through wrecks, though a considerable amount of insurance was carried on the vessels. In the application for receiver, which is made by Walter S. Besse on behalf of the company, the assets are stated to consist of twenty-four vessels, valued at $900,000 and worth at forced sale $613,000, and other sundry interests valued at $2,000; liabilities as figured out by Treasurer H. A. Harvey foot up about $1,000,000.

CORRESPONDENCE DEPARTMENT.

[Communications on matters of interest to marine engineers, for insertion in the correspondence department, are solicited. These, wherever possible, should be supplemented by rough sketches or drawings, which will be reproduced, if necessary to illustrate the subject, without cost to the writer.

Full names and addresses should be given, but publication of these will be withheld where requested.

We do not assume responsibility for the opinions expressed by correspondents.]

Efficiency of Naval Engineers.

Editor of Marine Engineering:

A correspondent who signs himself "Member Society S. N. A. & M. E." calls attention in a letter published in your January number to a statement credited to Lieutenant-Commander W. W. Kimball, U. S. N., and made at the late meeting of the Society of Naval Architects and Marine Engineers, as follows: "We have only very few officers of the Engineer Corps competent to give experienced trained engineering supervision to those repairs on torpedo boats which are attempted at Navy Yards, and those few are rarely available for the duty."

Your correspondent very properly states that if this be true the Engineer Corps should be "investigated" in the interest of the country at large. But it is, of course, not true, nor do I believe that Mr. Kimball ever intended to convey the idea which the words would seem to do.

The paper on "Torpedo Boat Utility," by Lieutenant-Commander Kimball, was, of course, read by me, and I noticed the phraseology referred to, but believed that what was intended to be said was that "We have only very few officers of the Engineer Corps to give the engineering supervision to repairs, etc., and those few are rarely available for duty." This construction brings us face to face with the fact that the Engineer Corps is much too small, and that of this small number there are very few who can be spared for duty on torpedo boats, or for shore duty at Navy Yards. This is undoubtedly the idea that Mr. Kimball meant to convey, as he is an officer of too much experience to believe for a moment that the Engineer Officers who superintend so successfully the repairs on our battleships and cruisers of various types are not competent to do similar work on torpedo boat machinery.

While in command of the torpedo flotilla Lieutenant-Commander Kimball appreciated the services of the one Engineer Officer who could be spared for duty with that little fleet, and he expressed his appreciation on more than one occasion.

GEORGE W. MELVILLE,
Engineer-in-Chief, U. S. N.

An Effective Quick Repair.

An experience I had with makeshift repairs not long ago would, I believe, interest many of your readers. At the time I was third engineer in the frozen mutton trade, sailing from River Plate to Liverpool. We finished loading our cargo, having about 18,000 frozen carcases in the after part of the ship and a general cargo forward. Our refrigerating plant consisted of a large cold-air machine driven by a compound steam engine supplied with steam from the main boilers. I might add that the machine did its work well, though it was rather extravagant on steam.

We left Buenos Ayres and all went on smoothly until the tropics were reached, when one morning we heard a crash in the machine room and a stoppage of the engine. On examination we discovered that the crosshead of the compression engine had broken, as seen in sketch *A*. The crosshead and piston rod for this engine were in a solid forging, and we had no spare one on board. Our machine was completely disabled, as we were dependent on the compression, cooling and expansion of air for the efficiency of the machine. As we were in the tropics, whatever was done

should be done quickly, as the temperature in the chambers would soon increase. So we took a spare crosshead bolt, flattened the head end like a palm stay and pinned it with two set screws to the piston rod, then coupled up and started the machine.

This arrangement only lasted about a quarter of an hour, when the bolt carried away at the weakened end. Then we decided to make a plate to pass over the piston rod, with holes for the crosshead bolts. We had no suitable iron in our engine room stores, so we took a small kedge anchor from the deck, cut a piece from it which was 4 in. thick, heated in the furnace fires and swaged it down to 2 3-4 in., which was the clearance between the heads of the bolts and the packing gland on the cylinder. Then we drilled three holes and had a plate something like the sketch *B*. Our spare crosshead bolts were too short, but fortunately we had spare ones belonging to the crank pin, which suited nicely. Making this plate with imperfect ship tools and drilling tackle took us considerable time and labor. Well, we put it in position, coupled all up and started the machine, which worked splendidly, and we thought our trouble for that voyage was ended.

About a week afterwards, when nearing the Cape De Verde Islands, we heard a peculiar knocking noise in the main engines, while the main bearing brass

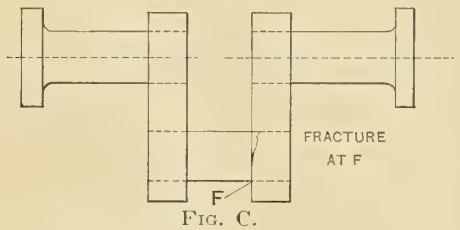


Fig. C.

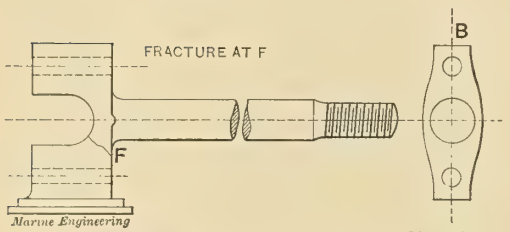


Fig. A. Fig. B.

next the after crank commenced to heat. We slowed down, and then noticed the webs of the after crank springing at each revolution. As the weather was squally, the skipper ran the ship under the lee of one of the islands and anchored for shelter. We then took off the crank pin brasses and found the crank pin broken just inside the web (Figure C). This was our after crank, but we had a spare crank that had been the forward one, and that had been taken out on account of a flaw. The chief engineer decided to fit it in the place of the broken one. We rigged blocks and tackle and let the tackle fall through the engine room skylight to a steam cargo winch on deck, disconnected the couplings and took out the shaft, which came away in halves. We then put in the spare one, and the couplings and bolts did not require very much fitting. We had to cut keyseats for the eccentric sheaves, which fitted on over the outside of the couplings. We did not waste much time fitting or scraping the crank pin and main bearing brasses, as we knew the shaft would require to be taken out again in Liverpool, so we coupled all up and proceeded under easy steam, after being stopped only twenty-eight hours—not a bad performance for four engineers and the ship's staff.

No other incident of note took place and we arrived in Liverpool safely and with our frozen meat in first class condition. W. T. Smith.

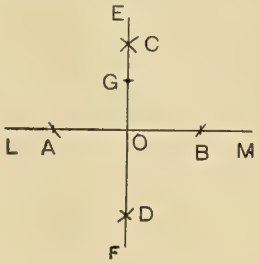
EDUCATIONAL DEPARTMENT.

CALCULATIONS FOR ENGINEERS—AN AID TO CANDIDATES FOR MARINE PAPERS—V.

BY DR. WILLIAM FREDERICK DURAND.

§ 10. PROBLEMS IN GEOMETRY.

[1] At any Point in a Straight Line to Erect a Perpendicular. Let *O* be the given point in the line *L M*. Then take points *A* and *B* such that *O A* = *O B*. From *A* and *B* as centers with any radius greater than *A O* or *O B*, describe arcs cutting in *C* or *D*, or if pre-

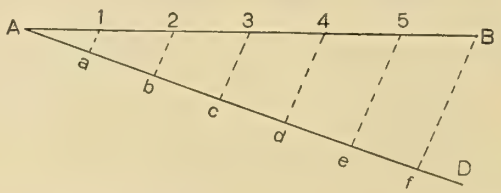


ferred, in both. Then a line drawn through *O* and *C* or *O* and *D* will be perpendicular to *L M*, or the line may be drawn through *C* and *D*, in which case it will also contain *O* and be perpendicular to *L M* as before.

[2] To Bisect[10] the Distance Between Two Points. In the figure for problem [1] let *A* and *B* be the two points. Then finding points *C* and *D* as in [1] it is plain that the point *O* determined by drawing the line *C D* will be the middle point between *A* and *B* as desired, and that we shall have *A O* = *O B*.

[3] To Find the Center from which to Pass an Arc of Given Radius Through Two Given Points. In the figure for problem [1] let *A* and *B* be the points. Then finding points *C* and *D* as in [1] it is plain that any point in the indefinite line *E F* will be at equal distances from *A* and *B*. Hence from *A* or *B* as a center and with the given radius cut the line *E F* in a point as *G*. This is the point desired.

[4] To Divide a Given Line Into a Given Number of Equal Parts. Let *A B* denote the given line. Draw a line *A D* at a small angle with *A B*, and lay off upon it as many equal divisions *A a*, *a b*, *b c*, etc., as it is desired *A B* shall have. These divisions should be



so chosen that the total length *A f* shall not widely differ from *A B*. Next draw *B f* and then a series of parallels through the points of division *a b c*, etc. The points where these lines cut *A B* will give the points of division desired.

[5] To Construct a Triangle, Having Given the Three Sides. Let *a b c* denote the sides. Take *A B* = *c*, and from *A* as center and with *b* as radius, describe an arc *D E*, and similarly from *B* as center and with *a* as radius describe an arc *F G*. These arcs intersect in *C*, and drawing lines *A C*, *B C*, the construction is completed.

[10] To *bisect* a geometrical quantity means to divide it into two equal parts.

[6] To Bisect a Given Arc or Angle. Let $A\ O\ B$ denote the angle and $A\ B$ the arc. From A and B as centers, and with any radius greater than half the distance between A and B, describe arcs intersecting in

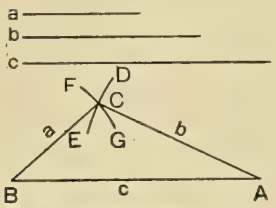


Figure for [5].

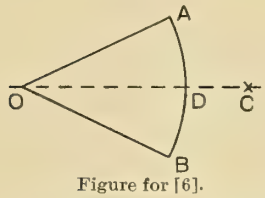
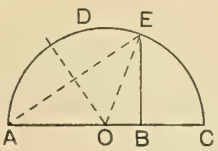


Figure for [6].

some point C. Then a line $O\ C$ will bisect the angle $A\ O\ B$ and at D the arc $A\ B$.

[7] To Construct a Mean Proportional[11] Between Two Given Lines. Let the two lines be denoted by $A\ B$ and $B\ C$ placed end to end. Find the



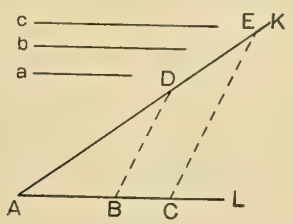
center O of the line $A\ C$, and describe a semi-circle $A\ D\ C$. Draw $B\ E$ at right angles to $A\ C$. Then $B\ E$ is the desired mean proportional, and we have:

$$A\,B : B\,E :: B\,E : B\,C$$
$$\text{or, } A\,B \times B\,C = B\,E^2$$

[8] To Construct a Fourth Proportional[12] to Three Given Lines. Let a, b and c denote the three lines, and let the desired proportion be:

$$a : b :: c : (\ )$$

Lay off $A\ B = a$ and $A\ C = b$. Then at any convenient



angle lay off $A\ K$ and take on it a distance $A\ D = c$. Draw $B\ D$ and $C\ E$ parallel to it. Then $A\ E$ is the fourth term desired and we have:

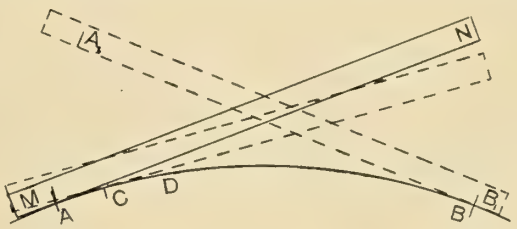
$$A\,B : A\,C :: A\,D : A\,E$$
$$\text{or, } A\,B \times A\,E = A\,C \cdot A\,D$$

[9] To Construct a Square Equivalent in Area to a Given Rectangle. Find by problem [7] a mean proportional between the sides of the rectangle, and this will be the side of the square desired.

[10] To Construct a Square Equivalent in Area to a Given Triangle. Find by problem [7] a mean proportional between the base and half the altitude, or between the altitude and half the base. This will be the side of the square desired.

[11] With One Given Side, to Construct a Rectangle Equivalent to a Square. This is equivalent in [7] to having given $A\ B$ the side of the rectangle and $B\ E$ the side of the square. Find by the use of the construction in problem [1] a point O on $A\ B$ at equal distances from A and E and describe the semi-circle. Then $B\ C$ is the remaining side of the rectangle desired.

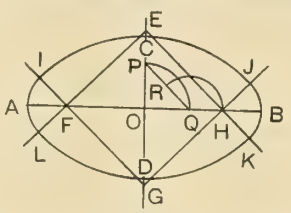
[12] To Find the Length of an Arc of a Curve. Let $A\ C\ D\ B$ denote the given arc. Take a strip of paper $M\ N$ and lay with an edge just neatly tangent to the curve at A. Mark a point opposite A on the strip. Then, placing the pencil at C, a point near where the curve and edge of the paper strip begin to separate, bear down slightly and rotate the paper about C as a center until the edge is tangent at C or at a point slightly beyond. Then move the pencil along



to a point D and repeat, and so on until the strip has been thus rolled along the curve to B. The distance $A_1\ B_1$, between the point opposite A on the strip at the start and the point opposite B at the end, will be very close to the true length of the curve. A little experience will enable the points $C\ D$, etc., to be so chosen that the error will be very small. A check on the operation may be obtained by reversing the process and rolling the paper back to the original position. If the point A_1 comes again to A it shows that no slip has been made, and the distance found may be accepted as a very close approximation to the true length of the curve.

[13] To Construct an Ellipse. Of the many methods available, three are given as follows:

(1) Given the two diameters $A\ B$ and $C\ D$. Take $B\ Q$ equal to $O\ C$ and then $O\ P$ equal to $O\ Q$. Draw $P\ Q$ and find R its middle point. Then take $Q\ H = Q\ R$, and $O\ E$, $O\ F$, $O\ G$ all equal to $O\ H$. Through E, F, G and



H draw lines as shown. Then with H and F as centers draw arcs $J\ K$ and $I\ L$, and with E and G as centers draw arcs $L\ K$ and $I\ J$. These arcs join and complete the contour. While this method is only approximate and does not give a true ellipse, it answers very

[11] A mean proportional between two quantities a and c is a third quantity b, such that we have:

$$a : b :: b : c$$
$$\text{or, } b^2 = a\,c$$
$$\text{or, } b = \sqrt{a\,c}.$$

See also § 6.

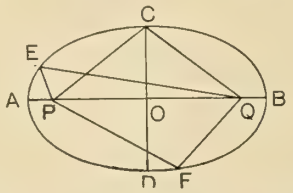
[12] A fourth proportional to three quantities a, b and c is a quantity d, such that we have:

$$a : b :: c : d.$$

See also § 6.

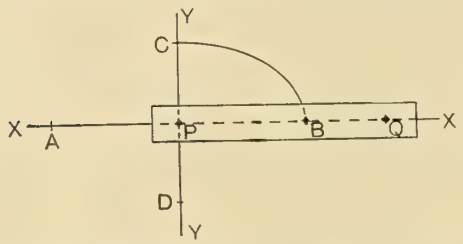
well for draughting purposes where a good representation of an ellipse is all that is desired.

(2) This method is exact in principle. Given *A B* and *C D* the two diameters as before. With *C* as center and *C Q* = *O B* as a radius find the points *P* and *Q*. These are the *foci* of the ellipse. Then adjust a thread



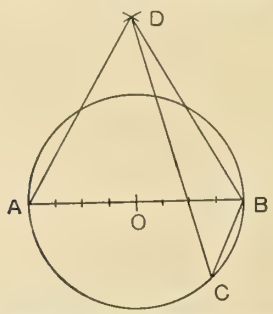
P C Q secured at *P* and *Q* and of a length *P C* + *C Q* = *A B*. A pencil carried around in the bight of this thread, as shown in different positions at *E*, *C*, *F*, will trace the ellipse desired.

(3) This method is also exact in principle. Given *A B* and *C D* the two diameters as before. Prepare a strip of cardboard or thin wood with holes *P*, *B*, *Q*, such that *P B* equals one-half *A B* and *B Q* equals one-



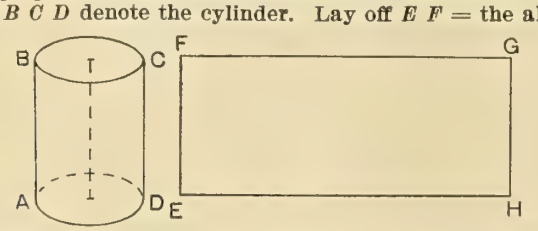
half *C D*. Then move the *trammel*, as it is called, so that *P* shall always move on the vertical *Y Y* and *Q* on the horizontal *X X*. The point *B* will then trace the ellipse desired. If points on the curve only are required, this method is readily applied.

[14] To Construct any Regular Polygon (approximate). Let *A B* denote any diameter of the given circle within which the polygon is to be inscribed. Divide *A B* into as many parts as there are to be sides in the polygon. From *A* and *B* as centers and radius *A B*



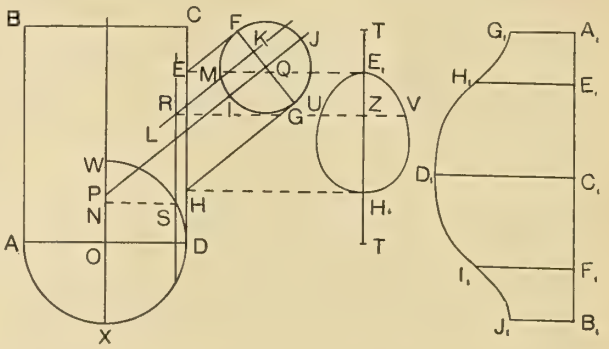
describe arcs cutting in *D*. From *D* draw a line *D C* through the second of the points of division. Then *B C* is the side of the polygon desired within a very small error. For the square or hexagon, or when the number of sides is 4 or 6, the construction is exact.

[15] To Develop the Surface of a Cylinder. Let *A B C D* denote the cylinder. Lay off *E F* = the alti-



tude and *E H* = the circumference of the base, = π× diam. = 3.1416 × diam. Then the rectangle *E F G H* represents the development desired.

[16] To Develop the Surface of a Cylinder Which is Intersected by Another Cylinder, the Two Axes Being in the Same Plane. The developed form of the intersection is the only part requiring special notice. Let *A B C D* and *E F G H* denote the two cylinders. Draw any line *T T* to denote the element *C D* in the developed surface of *A B C D*. Then the developed form of the intersection will be symmetrical about *T T*. Project *E* and *H* over to E_1 and H_1 for the top and bottom of the curve. Then to find intermediate points proceed as follows: Draw any line *K L* parallel to *P Q* and denoting the edge of a plane per-

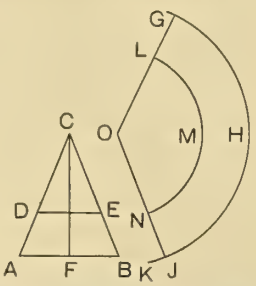


pendicular to the paper and cutting both cylinders. With *F G* as diameter describe the circle as shown, and with *A D* the semicircle *W D X*. Make *N O* equal to *M K* and project over to *S*, thence up to *R* and then over to *T T*. Rectify the arc *S D* and lay off *Z U* and *Z V* each equal to the rectified length. Then will *U* and *V* be points on the curve as desired. Other points may be found in a similar manner and the curve filled in.

To develop the form of the smaller cylinder proceed as follows:

Let C_1 D_1 denote in the development the element *H G*. Lay off A_1 B_1 = the circumference *I F J G*. Then for the points corresponding to the plane *K L* take C_1 E_1 = C_1 F_1 = the developed length of the arc *G M*. Then draw E_1 H_1 and F_1 I_1 each equal to *K R*. This will give two points, H_1 and I_1, and others may be found similarly and the curve filled in as shown.

[17] To Develop the Surface of a Cone. Let *A B C* denote the cone. With *A C* as radius and any point *O* as center, draw an arc, *G H K*. Then lay off

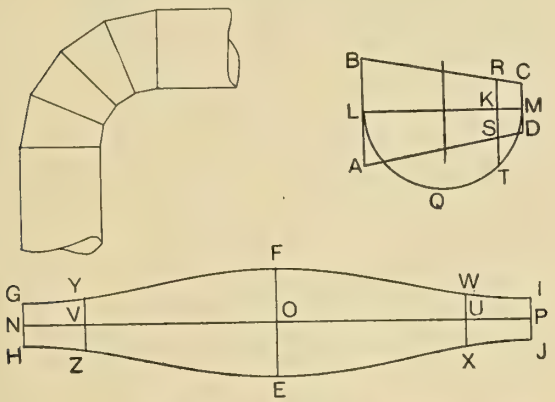


the circumference of the base *A B* (= 3.1416 × *A B*) on a strip of paper, and lay off this length by rolling as in problem [12] from *G* to some point *J*. Then the arc *G H I* = circumference of *A B* and the sector *O G H J* is the developed surface of the cone.

[18] To Develop the Surface of the Frustum of a Cone. Referring to the figure for the preceding problem, let *A D E B* denote the frustum. Then, after proceeding as in that problem, take next a radius *O L* = *C D* and describe the arc *L M N*. Then will the sector *O L M N* represent the surface of the cone

C D E, while the strip *L G H J N M* represents that of the frustum.

[19] To Develop the Segments of an Elbow. These are portions of a cylinder cut by oblique planes. Let *A B C D* denote such a segment. Draw *L M* perpendicular to *A B* and construct the semicircle *L Q M*. *L M* may be placed at any convenient location between *B C* and *A D*. In the development let *E F* denote the element *A B*. Make *F O = B L* and then draw perpendicular to *E F* lines *N O = O P =* each to the semicircumference *L Q M*. Then *N P* is the development of



L M. Lay off *N G = P I = M C* as shown. Then to find intermediate points on *G F I* take any line *R S* and project down to *T*. Develop *L Q T* and lay off the developed length at *O U* and *O V*. Then make *V Y* and *U W* each equal to *K R*, and *Y* and *W* will be points on the development of *B C*. Other points may be found in a similar manner and the development of *B C* completed as shown by the curve *G F I*. The curve *H E J* as the development of *A D* may be found in an entirely similar manner, and if *B C* and *A D* are equally inclined to the elements of the cylinder, *L M* will naturally be located midway between them, and *H E J* will be symmetrical with *G F I* about *N P*, and both may thus be found at the same time by laying off above and below *N P* the distances determined as above shown.

§ 11. PHYSICS.

[1] Acceleration Due to Gravity. In engineering computations there frequently enters a quantity known as the *acceleration of gravity* or the *acceleration due to gravity*, and denoted by the symbol *g*. This is the change per second which the gravity or attraction of the earth is able to bring about in a freely falling body. For engineering purposes its value is usually taken at 32.16 or 32.2.

[2] Specific Gravity. The specific gravity of a given substance is the relation between the weights of equal volumes of the given substance, and of some standard substance, usually water. Thus a specific gravity of 8 means that, volume for volume, the given substance is 8 times as heavy as water.

[3] Heat Unit. Heat is measured in terms of a unit defined as the amount of heat required to raise 1 lb. of water 1 deg. in temperature at 60 deg. Fahrenheit, or from 60 deg. to 61 deg.

[4] Specific Heat. The specific heat of a substance is the relation between the amount of heat required to raise it 1 deg. at the given temperature and under given conditions as to pressure or volume, and the unit of heat as just defined. Thus a specific heat of .32 means that under the given conditions it will require, to raise the temperature 1 deg., .32 of the heat necessary to raise 1 lb. of water from 60 deg. to 61 deg.

[5] Expansion of Metals. Nearly all substances expand with the addition of heat, and usually with nearly equal amounts per degree rise of temperature, especially where the substance is not near its melting or boiling point. The following table gives the *coefficient of linear* or *length expansion* for various substances. This is the expansion in unit length for 1 deg. Fahr. rise of temperature.

Substance.	Coef.	Substance.	Coef.
Aluminum	.0000123	Iron, cast	.0000056
Brass, cast	.0000096	Iron, wrought	.0000065
Brass, drawn	.0000105	Lead	.0000157
Brick	.0000031	Mercury	.0000333
Bronze	.0000099	Steel, cast	.0000064
Bismuth	.0000098	Steel, wrought	.0000069
Concrete	.0000080	Tin	.0000116
Copper	.0000089	Zinc	.0000141
Glass	.0000045		

To find the expansion in the length of any bar for any given rise in temperature we have the following:

Rule—Multiply the coefficient taken from the table by the number of degrees, and this by the length of the bar, and the product is the expansion desired.

Example: What is the expansion of a steel bar 20 ft. long between 60 deg. and 350 deg. Fahr.?

Ans.: .0000069 × 290 × 20 = .04 ft. = .48 in.

The coefficient for area or surface expansion is taken twice that for linear expansion, and that for cubic or volume expansion is taken three times that for linear expansion.

Example: What is the increase in area between 60 deg. and 300 deg. Fahr. in a copper sheet having an area of 54 sq. ft.?

Ans.: .0000178 × 240 × 54 = .231 sq. ft. = 33.3 sq. in.

What is the increase in volume between 100 deg. and 200 deg. Fahr. in a piece of brass having a volume of 2 1-2 cu. ft.?

Ans.: .0000288 × 100 × 2.5 = .0072 cu. ft. = 12.44 cu. in.

§ 12. MECHANICS.

[1] It is a general law of nature that all bodies tend to remain unchanged as regards their condition of rest or relative motion. A body at rest does not move unless caused to do so by some outside agency. A body in motion continues to move until it is brought to rest by outside agencies such as friction, resistance of the air, or of water, etc.

[2] Force. Any agency which changes or tends to change the condition of a body as regards its rest or relative motion is called a *force*. For engineering purposes force is measured by the *pound* or *ton* as unit. In marine engineering the ton, unless otherwise stated, is usually of 2,240 lb.

[3] Specification of a Force. A force has three characteristics or particulars:

(1) Its line of direction, as north and south.
(2) The way it acts in that line, as north.
(3) Its magnitude.

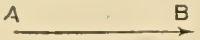
A force may therefore be completely represented by a line *A B* of length to represent the magnitude, and

A ——— B

drawn in the direction of the line of action of the force.

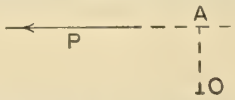
Thus the force *A B* would mean a force represented in amount according to some scale by the length *A B*, and acting along the line *A B from A to B*. The direc-

tion of action is also frequently denoted by an arrow point, thus:



[4] Moment of a Force. This is the product of the magnitude or measure of the force multiplied by the perpendicular distance from its line of action to a given reference point.

Thus in the figure let the full line represent a force, P denote its measure, and O the reference point. Then



$P \times O\,A$ is the moment of the force P about the point O. In the term *moment of a force* a point of reference is therefore always implied.

[5] Resultant. The resultant of a system of forces two or more in number with their lines of action all meeting at a common point, is the single force which represents the combined action or result of the system.

[6] Work. Work is done when a force (or resistance, as it may be called in such case) is overcome; as for example when a weight is lifted or a ship is forced through the water. Work is measured by the product of the resistance by the distance through which it is overcome. The two essential factors of work are therefore *force* or *resistance* on the one hand, and *motion* or *distance* on the other. The unit of work is the *foot pound* or the work done in raising one pound weight one foot in height. Thus if 16 lb. be lifted 20 ft. the work done is $20 \times 16 = 320$ ft. lb.

[7] Power. Work in itself is independent of the time required to do it, and depends simply on *resistance* and *distance*. Power means a certain amount of work performed in a given time. The common unit is the *horse power*, which is 33,000 ft. lb. of work performed in one minute. The added element involved in power should not be forgotten. Thus 33,000 ft. lb. of work performed in 1 hour would not mean one horse power, but only $\frac{1}{60}$ of such amount, while 33,000 ft. lb. of work performed in 1 second would mean 60 horse power. Likewise 550 ft. lb. per second represents one horse power as also 1,980,000 ft. lb. per hour. To find the horse power in any given case we have therefore the following:

Rule—Find the foot pounds of work performed per minute and divide by 33,000.

Example: An engine in one-half hour performs 118,800,000 ft. lb. work. What is the horse power?

$$\text{Horse power} = \frac{118{,}800{,}000}{30 \times 33{,}00} = 120$$

[8] Energy. This is the capacity for performing work, and depends on special conditions of motion or location. For convenience energy is considered of two kinds.

Kinetic Energy is the energy possessed by a body in virtue of a condition of motion. As we know, such a body resists an attempt to stop it, and it will overcome a certain resistance through a certain distance before being brought finally to rest. This kind of energy is measured by the formula $E = \frac{W v^2}{2 g}$ where W is the weight in pounds, v is the velocity in feet per second, and g is the acceleration due to gravity or 32.2. Since energy is directly convertible into work it must be really similar in character to work, and we may therefore speak of so many foot pounds of energy, just as well as of so many foot pounds of work.

Potential Energy is the energy possessed by a body in virtue of its location or condition relative to the forces acting on it. Thus a weight lifted to the top of a building has potential energy relative to the street because it could do work if allowed to move downward. Similarly a compressed spring or a compressed gas has potential energy because either, if properly allowed to return to the condition toward which it tends, will perform work. Potential energy is measured by the work which could be thus performed, or by its equal the work which must be done upon the body in order to produce the given condition; as for example the work done in lifting the weight to the top of the building, or in compressing the spring or gas. Potential energy is therefore measured directly in foot pounds.

[9] Conservation of Energy. It is a fact of universal experience that energy can neither be destroyed nor created. If it seems to disappear or to appear, it is but apparent, and the result simply of a change of form. Energy may exist in a variety of forms, as (1) Mechanical, (2) Thermal, (3) Electrical, (4) Chemical, and *when there is an increase in any one form there must be an equal decrease in one or more of the other forms*, and likewise *when there is a decrease in any one form there must be an equal increase in one or more of the other forms*. There may be a like exchange between kinetic and potential energy, the one increasing as the other decreases, and *vice versa*. Thus with mechanical energy if there is no change to other forms we shall find that the sum of the kinetic and potential energies is always the same, and that one increases as the other decreases and *vice versa*. In this view work simply appears as an attendant upon the exchange of energy, or more definitely, as a measure of the exchange. Again if we fix our attention upon one body, its changes of total energy measure the work which it receives or gives out. If its energy increases it has had work done upon it. If its energy decreases it has given out work to some other body.

[10] Statics. If the forces which act on a body are properly related or balanced, the body remains at rest. The conditions necessary to the realization of this state of rest under the action of forces form the subject of *statics*.

[11] Dynamics. If the forces are not so related, the body does not remain at rest and motion results. The amount and nature of such motion and its relation to the system of forces form the subject of *dynamics*.

Chief Engineer Walter M. McFarland, U.S.N., has obtained a six months' leave of absence and associated himself with the Westinghouse Electric and Mfg. Co., at Pittsburg, Pa., where he will hold the important position of Assistant General Manager. His resignation from the Navy is to take effect at the end of his leave of absence. At the time of his leaving the Naval service Mr. McFarland was assistant to Engineer-in-Chief George W. Melville and was also prominently identified with the splendid *Journal of the American Society of Naval Engineers*. Mr. McFarland is widely known in engineering circles at home and abroad: he not long ago was appointed to represent the United States Navy at the International Congress of Naval Architects and Marine Engineers in London. We understand that in his new position he will receive a salary very much larger than that which he could hope to draw from the Government service. He carries with him to his new sphere of action the sincere good wishes of his naval associates and those outside of the Department who have known him as an estimable gentleman and an engineer of great ability.

HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—FUELS—II.

BY DR. WILLIAM FREDERICK DURAND.

[5] Spontaneous Combustion. We have already seen under the head of *weathering* that coal at ordinary temperatures is subject to a very slow oxidation, or combustion, which gradually wastes away its fuel value. Also that a necessary consequence of this is the slow development of heat. Now, if the coal is in small bulk and well ventilated, there will be little chance for the gradual accumulation of the heat and a consequent rise of temperature. A few lumps of coal exposed to the open air may lose much by weathering in the course of six months or a year, but the heat set free will readily escape and the rise of temperature will be unnoticeable. If, on the contrary, the coal is in large bulk, or is confined in bunkers with little or no ventilation, the heat developed by slow oxidation will be imprisoned and the temperature may gradually rise to the point where active combustion will proceed according to the supply of air available. In such case, however, the limited supply of air tends to limit the progress of the combustion, and it might therefore at first sight seem a question which arrangement of the two would be better—good ventilation with a copious supply of air and consequently a low temperature, or poor ventilation with rising temperature, but with a limited supply of air for the support of the oxidation. General experience indicates that good ventilation provides much the safer arrangement of the two; that is, it is considered safer to provide plenty of air and keep the temperature down rather than to limit the supply and at the same time imprison the heat developed by what air may be available. Since, also, as explained in [4], the hydrocarbons are more subject to this slow combustion than carbon alone, it is clear that the danger of spontaneous combustion will be much greater with bituminous than with anthracite coal. In fact the latter variety of coal may be considered as beyond the danger of spontaneous combustion under all ordinary circumstances. On the other hand, only too many cases of spontaneous combustion with different varieties of bituminous coal are on record.

The general conditions favorable to spontaneous combustion are the following: A large mass or bulk of coal, confinement or poor ventilation, high temperature, and a quality of coal rich in the lighter and more readily oxidized hydrocarbons.

Iron pyrites has sometimes been thought a possible cause of spontaneous combustion, but the proportion of this substance is usually small, rarely rising above four or five per cent, and the heat developed by the combustion of sulphur and iron is also much less per pound than for carbon and hydrogen. The heat developed by the oxidation of iron pyrites is therefore hardly sufficient to do more than help along the general condition of slow combustion, which, with light hydrocarbons and other favorable conditions, may result in spontaneous active combustion. The fact that cases of spontaneous combustion are more commonly met with in coal especially rich in light hydrocarbons rather than in that having a high percentage of iron pyrites, also shows that the former rather than the latter is to be considered as the responsible cause.

The gases imprisoned within the coal, reference to which was made in [4], may also escape and collect in a closed and unventilated compartment or bunker, and upon the later introduction of a light an explosion may result. This is exactly similar to the way in which firedamp explosions in mines may result. Thorough ventilation of such bunkers or spaces is the safeguard against such danger, and it should not be neglected, especially with coal of a quality likely to freely disengage such gases.

[6] Corrosion. As a further possible result of the presence of iron pyrites and the sulphur which is one of its constituents, the corrosion of the metal surfaces of the boiler may be mentioned. Sulphur in burning in the presence of moisture may produce sulphuric acid, and this may seriously corrode such surfaces as it comes in contact with, especially if there is opportunity for its gradual action during periods when the boiler is not in active use. The conditions necessary for the formation of sulphuric acid are, however, not commonly present in marine boilers, and the danger of corrosion from the combustion of iron pyrites is not usually considered as serious.

[7] Transportation and Stowage. In general anthracite coal bears transportation and handling better than bituminous on account of its greater hardness. It also stows more evenly on account of the greater uniformity in size of lump.

The weight of coal in the solid lump is from 70 to 80 lb. per cubic foot for bituminous grades, and from 85 or 90 to 100 lb. per cubic foot for anthracite grades. When broken up in ordinary commercial sizes, however, its weight in bulk is usually from 50 to 54 lb. per cubic foot for bituminous, and from 53 to 58 lb. per cubic foot for anthracite. These weights correspond to an allowance of from 42 to 45 cu. ft. per ton of 2,240 lb. for bituminous grades and from 39 to 42 cu. ft. per ton for anthracite grades.

[8] General Comparison Between Bituminous and Anthracite Coal. As between the two kinds of coal, bituminous burns more readily than anthracite, and requires a somewhat lower temperature for the process. This is because with the former the hydrocarbon gases are first driven off and burnt, while the coke residue is left in a light and porous condition, and thus well suited for intimate contact with the oxygen, and for rapid elevation to the temperature of ignition. On the other hand, with anthracite coal the hydrocarbon gases are so small in amount as to have little influence on the process, and the coal has therefore to burn as compact, solid lumps of carbon, with little opportunity for contact with the oxygen except at the outer surface.

It results that under the same conditions of draft, firing, etc., considerably more coal can be burned per square foot of grate surface with bituminous than with anthracite. The excess of the former will depend, of course, on the special conditions, but will usually reach from 20 per cent to 40 per cent, or even more.

From the explanation given in [2] it will be clearly seen that smoke and soot are chiefly the products of bituminous coal. With anthracite coal, immediately after firing, a slight show of smoke may be formed, but with neither the volume nor density of the smoke formed by bituminous coal, while the soot formed with anthracite is too small in quantity to be of any significance.

Bituminous coal, as we have seen, is more liable to spontaneous combustion than anthracite, and the loss by weathering is usually more serious.

A good quality of free-burning semi-bituminous coal is usually considered as the best variety for all around steaming purposes.

§ 2. BRIQUETTES AND ARTIFICIAL FUEL.

This fuel is made from small bits of coal, coal dust, or from certain grades of coal which are so soft or crumbling that they cannot be readily used in their natural state. The material after selection and removal of impurities, so far as practicable, is reduced to powder by grinding, and is then mixed with some binding material and pressed into cubes or blocks weighing from one to three or four pounds each. The binding material is usually coal-tar, asphalt, crude oil refuse, or some similar substance. In some cases a

caking coal has been used by heating until softening occurs and then pressing into moulds while hot.

The character of such fuels will of course depend on the nature of the materials of which they are made. By a proper choice of the ingredients or by a suitable enriching with hydrocarbons in the form of pitch or crude oil, a fuel of most excellent quality may be made. The pressure to which the blocks are subjected is so great that the materials become closely compacted together and hold their form with no more breakage through handling than with a good quality of semi-bituminous or even semi-anthracite coal. The best grades of artificial fuel ring when struck and absorb little or no water, thus showing a compact and firm structure throughout. They ignite readily and burn freely without an excessive formation of smoke, holding their shape without crumbling too rapidly on the grate. In evaporative power the best briquettes are the equivalent of good coal, from which indeed they differ chemically in no essential character.

The weight per cubic foot and the number of cubic feet per ton when stowed loosely are about the same as for good semi-bituminous coal of like quality. If packed regularly the waste space is much decreased and the cubic feet per ton will be reduced to from 25 to 35.

§ 3. LIQUID FUEL.

[1] Composition. The only liquid fuel of importance to the engineer is either crude petroleum oil, or the residue left after removing from the crude oil by distillation the lighter constituents, consisting of naphtha, illuminating oil, etc. Crude petroleum oil is a liquid of brownish tint varying from light straw almost to black. It consists of a very complex mixture of many hydrocarbons. Some of these vaporize very easily and escape rapidly, even at ordinary temperatures. Such constitute the naphthas and gasoline. Next in order come the constituents which form common illuminating oil or kerosene. Then still heavier and denser come the lubricating oils of various kinds. After the removal of these there still remains a residue capable of yielding paraffine and vaseline, and last of all a certain amount of gas tar and coke.

When the process of refining or distillation is arrested after the removal of the naphthas and illuminating oils and perhaps some of the lubricating oils, the residue consists of a rather thick viscid liquid, not readily ignited as compared with the crude oil, but under proper conditions burning readily and with great heating power. Such residue in the Russian oil wells on the Caspian is called *astatki*. It constitutes more than one-half of the crude oil. On the other hand, with American oils the similar residue is much less in amount, rarely rising to one-third of the crude oil. Furthermore the processes of refining are so much superior in the United States that of final residue after the removal of all marketable products, there is almost nothing left. With the best modern methods of treatment, therefore, the use of the residue after partial refinement does not mean the utilization of a waste or by-product, but the use of a substance having a definite market value for other and long established uses. For the direct use of crude oil the same is true in still higher degree, so that under modern conditions the use of liquid fuel means simply a competition with the various other industries involving the use of the various products of crude petroleum oil.

[2] Combustion. For the combustion of crude oil or liquid refuse, the chief essential is that it must be "pulverized" or "atomized"—that is, broken up into a very fine spray and thus brought into intimate contact with the oxygen of the air. This is accomplished by special devices fitted to the furnace and called "pulverizers" or "atomizers." They are of two chief varieties according to the means used—either compressed air or steam. In each the oil is fed by pump or allowed to flow by gravity to the nozzle of the device. Here it is caught by a jet of air or steam, as the case may be, issuing near or through it, and by this means is thoroughly broken into a fine spray and blown into the furnace in this condition. Once the fire started, the spray is ignited as it issues from the nozzle so that the result is a long, fiercely burning jet of flame directed into the furnace. In order to produce the conditions best for complete combustion, it is usually found advantageous to have fire brick so disposed as to take the direct action of the flame. These bricks become heated to a high temperature and by their radiating action help to produce and maintain a temperature suitable for the complete combustion of all gaseous products formed from the liquid spray.

Under proper conditions oil may thus be burned with little or no formation of smoke or soot. The absence of all soot is especially favorable to the maintenance of a high efficiency of operation. There is furthermore no clinker or ash, no cleaning of fires, no opening of furnace doors either for firing or cleaning, and no handling of ashes.

[3] Danger of Explosion. The danger of explosion or of the formation of an explosive mixture by the slow distillation of the lighter hydrocarbons is considerable with crude oil unless due attention is given to the airing and ventilation of the spaces where such gases can collect. So long as the spaces containing oil are full there is no danger of any such trouble, but when they are partially empty the gases may collect in the vacant parts, forming with the air an explosive mixture which needs only a spark or other source of fire to explode with violence. Crude oil residue does not contain these lighter substances and is therefore safe from danger of this character, though in all cases a due attention to the matter of ventilation may be recommended. It may also be noted that the more dangerous parts of the oil evaporate with readiness under ordinary temperatures, and that crude oil exposed to the open air rapidly loses these constituents and becomes thereby the safer for use. This operation corresponds to the *weathering* of coal, and entails of course some loss, but a loss the more permissible as it makes the fuel the safer to use.

[4] Evaporative Power. Liquid fuel has a much ligher evaporative power pound for pound than coal. According to chemical analysis the combustion of one pound of liquid fuel should liberate from 20,000 to 22,000 heat units, or about one and one-half times as much as good coal. This, combined with better efficiency of operation than with coal, have given experimental results showing an evaporative power twice that of coal or even higher. A ratio of 1.7 : 1 or 1.6 : 1, however, is more commonly considered as representing the average relation under ordinary conditions, though in some cases the advantage has been still less marked.

[5] Stowage and Handling. The best oil residue is of about the same density as sea water or slightly heavier. It will thus run from 34 to 35 cu. ft. per ton. While therefore its specific gravity is less than that of a lump of coal, it stows much better, so that a given space is capable of holding from 15 to 20 per cent more fuel in the shape of oil than in the shape of coal. Combining this advantage with that in evaporative power per pound, it follows that the final result is to very nearly double the capacity for steam generation per cubic foot of space occupied by fuel. As a further point it may be mentioned that oil or liquid fuel may be stowed in many places on board ship not available for coal or for cargo in general. Such are ballast tanks, double bottoms, etc. Again, the ease with which oil may be handled, flowing as it does by gravity and stowing itself, is a further point in its favor. With proper facilities a ship may be provided with oil much more rapidly than with coal. It should be added,

however, that oil refuse at a low temperature may become quite stiff, flowing only sluggishly, especially in small pipes. This condition may require the provision of special means for heating the oil so as to insure the necessary degree of fluidity. Oil refuse is therefore not a fuel suitable for arctic exploration.

A further advantage for liquid fuel lies in the great reduction in the fireroom force which is possible with its use. The handling and firing being practically automatic, only a few men are required to look after the oil tanks and supply pipes in a general way, and one fireman can give to a large number of furnaces the slight general attention which they require. The chief work in the fireroom is therefore reduced to water tending, which remains as with coal.

[6] Use of Oil and Coal Combined. In some cases the use of oil in conjunction with coal has given promise of good results, especially on war ships, where it may be of the utmost importance to be able to very rapidly increase the power developed. In such cases the coal would be used alone under ordinary conditions, and oil added when the increase of power is desired. Experiments in the Italian Navy show that for the most complete combustion and best efficiency the proportion of oil to coal should be about one of oil to five of coal. In the same manner as above described the oil is pulverized and blown as a spray into the furnaces, where it burns with the gases given off by the coal. In this way the oil furnishes a powerful resource for suddenly forcing the fires and increasing the I. H. P. developed while the amount of oil carried or consumed is quite small compared with the supply necessary if oil were the only fuel used.

[7] Cost. The great drawback regarding oil fuel, and one that is apparently too serious to be overcome, is that relating to its price. At ordinary figures a pound of steam would now cost at least as much if generated by means of oil as by means of coal, and if the use of oil were undertaken by several large steamship companies or other large consumers, its price would rise to a point impossible at present to foresee. The use of liquid fuel is quite within the reach of present engineering means, and may be considered as a mechanical success. Due however to the limited supply, and to the uncertainties regarding its price, its use will probably, under present conditions, be quite limited as a fuel for the generation of steam.

The British Admiralty Court has decided that the French line steamship La Bourgogne was altogether responsible for the collision with the British ship Cromartyshire, on July 4 last, near Sable Island, which resulted in the loss of the steamship and 550 lives. The Court held that the speed of the La Bourgogne at the time of the collision was excessive, considering all the circumstances, and that the Cromartyshire did everything possible to avert the collision. A number of damage suits are now pending against the French company, brought by the heirs of persons lost in the collision. Complete report of the mishap was published in our August, 1898, issue.

In a new form *The Nautical Gazette*, formerly and for a number of years known as *Seaboard*, the New York weekly publication, comes to hand. Instead of a sheet about 12 in. by 16 in., it is now issued in the convenient form, 8 in. by 11 in., and has an attractive cover. The character of the paper has been changed so that the political discussions with which it had long been identified are replaced by practical newsy and technical articles of general interest to those engaged in marine affairs. The management is now exclusively in the hands of W. H. and S. W. Stanton, the former partner, Alexander Smith, having retired to accept a state office. It is an old established journal and we wish it much prosperity in its new form and under its enterprising management.

ENGINEERS' DICTIONARY—XIV.

Excentric.—In general anything which is not truly centered or properly lined up with reference to some axis of rotation, or line of motion.

In particular an excentric is a circular disk, as in Fig. 51, attached out of center to the shaft of an engine. From the excentric by means of the excentric strap and rod is derived the motion for the valve which regulates the admission and exhaust of steam into and from the cylinder. The motion given by the excentric is exactly the same as that which would result from a crank of a throw equal to the distance from the center of the excentric to the center of the shaft. This distance is therefore called the *throw* of the excentric, although in some cases this term is used to signify twice this distance, or the whole distance traveled by the valve. Excentrics are usually of cast iron or occasionally of cast steel, made in two parts, bolted together, and keyed in place on the shaft. The excentric shown in Fig. 51 is designed for a large marine engine. As shown, the excentric sheave is made in two unequal parts which come together at the diameter of the crank shaft so that the excentric can be readily fitted in place or removed without moving the heavy crank shaft. The faces where the two portions of the sheave join are tongued and grooved, making practically a solid sheave when bolted together. The heavy black lines show metal liners to take up wear.

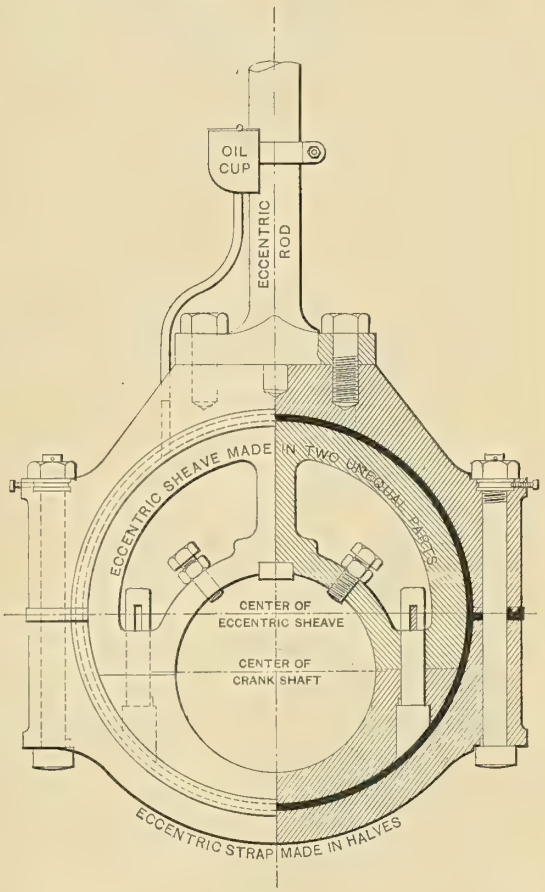

OIL CUP
ECCENTRIC ROD
ECCENTRIC SHEAVE MADE IN TWO UNEQUAL PARTS
CENTER OF ECCENTRIC SHEAVE
CENTER OF CRANK SHAFT
ECCENTRIC STRAP MADE IN HALVES

Fig. 51.

Excentric Rod.—The rod, Fig. 51, by means of which the motion of the excentric is communicated to the link, and thence to the valve.

Excentric Rod Fork.—A forked or U shaped upper

end usually given to the excentric rod, to facilitate its attachment to the link, Fig. 52.

Excentric Sheave.—The same as excentric above.

Excentric Strap.—The ring of metal which surrounds the excentric and forms with it the turning pair. The excentric in its motion around with the shaft turns within the strap and at the same time carries it to and fro. This latter motion is then, by means of the excentric rod and link, transmitted to the valve as already noted. Excentric straps are made in halves and bolted together. The material used is usually cast steel or bronze, and the inner surface is lined with white metal to give a bearing surface on the excentric. Brass or bronze may also be used as a liner for cast steel straps, while the white metal is sometimes omitted when the straps are of bronze. See Fig. 51.

Effective Horse Power.—The resistance which a ship would present if she were towed through the water at the given speed is called the *true* resistance. The work necessary to overcome this true resistance is called the effective horse power and is commonly

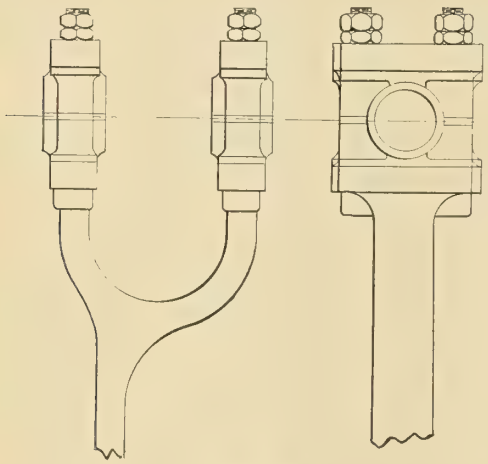


FIG. 52.

denoted by the initials E. H. P. It is only a fraction of the total indicated horse power, the remaining part having been expended in the friction of the engine and in the necessary work done on the water in obtaining the required propulsive thrust. The fraction usually realized is from 50 per cent to 60 per cent. This ratio is called the *propulsive coefficient.*

Effective Pressure.—In a steam engine cylinder there is always pressure on both sides of the piston. The effective pressure is the difference of these, or the net pressure acting in any one direction. Thus for example a pair of indicator cards may show at a given point in the stroke in the H. P. cylinder, say, that the pressure on top of the piston was 155 lb. per square inch while that on the under side was 90 lb. The effective pressure was therefore 65 lb. per square inch downward.

Efficiency.—This term always means a ratio of *returns* to *expenses.* Thus in a boiler the efficiency is the ratio of the heat transferred into the water to the total heat in the coal thrown through the furnace doors. The latter is the expense, the former the return. In the engine the expense is to be considered as the heat in the steam which is used, while the return is the indicated horse power developed. The efficiency is the ratio of the latter to the former. If we consider the return as the power delivered to the propeller, thus including the loss due to friction, then the efficiency of the engine becomes correspondingly less. In a propeller the expense is the work delivered to it from the shaft. The return is the work done by means of the thrust developed. The efficiency is the ratio of the latter to the former.

Ejector.—See **Bilge Ejector.**

Escape Pipe.—A pipe through which steam or water which has escaped through a safety or relief valve is led to a proper point for discharge. Thus on many steamers the main escape pipe leads from the main boiler safety valves up alongside the funnel to a suitable height for the convenient discharge of the steam.

Escape Valve.—A form of safety valve allowing the escape of steam or water when the load becomes greater than that for which the valve is set. On steam cylinders they are more commonly known as *relief* valves, and are made as in Fig. 53.

Evaporation.—A term referring in general to the change of water from liquid into steam. The word is also used in reference to the amount of water evapo-

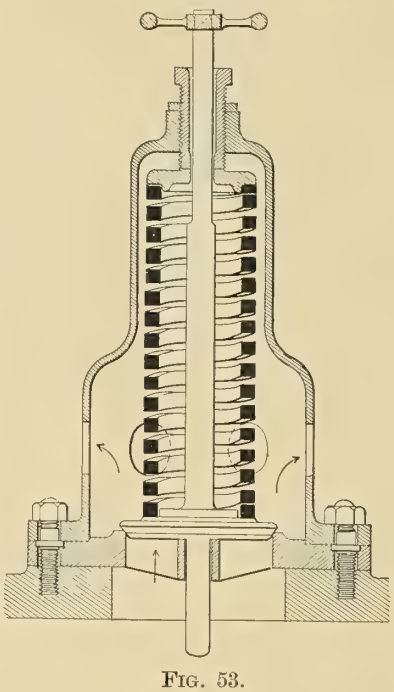


FIG. 53.

rated in the boiler per pound of coal burned on the grate. With hard forced draft, coal of poor or moderate quality, and poor firing, the *evaporation* may be no more than 7 lb. or even less. Under favorable circumstances with efficient combustion and good coal the *evaporation* may rise to 10 or 11 lb. or slightly over. Values of from 9 to 10 lb. are representative of good average conditions.

The arrival of the battleships Oregon and Iowa and the supply ship Celtic at Rio Janeiro in November was made the occasion of a hearty demonstration on the part of the English speaking colony there, which was participated in by the crews of the British warships Flora and Beagle, on that station.

The revenue cutter McCulloch, Captain Hooper, arrived at San Francisco January 10 after a voyage from Manila. Our regular readers will recall that an extensive description of this vessel was published in our June, 1897, issue. She was built for service in the Behring Sea and was on her way out, via the Suez Canal, when the Spanish war broke out. She was then impressed into the naval service and joined Admiral Dewey's fleet at Singapore, accompanying the fleet to Manila before the battle of Cavite. Her commander reports that on her voyage home she behaved admirably in rough weather, maintaining a speed of about 12 knots.

THE ART OF MAKING MECHANICAL SKETCHES —FOR MARINE ENGINEERS—VI.

BY PROF. C. W. MAC CORD.

What precedes has been mainly a brief explanation of the methods and principles of orthographic projection as used in the construction of mechanical drawings. These apply equally well to the making of working sketches; it has been remarked that a sketch is (in many cases at least) simply a rough drawing, made possibly without the use of instruments, but at any rate made so as to resemble an accurate working drawing as nearly as may be; so that some knowledge of the theory is necessary in order to make such sketches intelligently and rapidly.

Clearly, a sketch should contain all the data required for the reproduction of the object represented, and should convey its information in the most direct manner, with the least possible labor. It is therefore important to decide at the outset just what views are best adapted to this end, and to make those and no more.

Take for example the crank and part of shaft shown in Fig. 28; a glance at this figure shows that by its aid the pieces could be made, and that with no chance of error; the side view and end view are absolutely necessary, while a top view would be utterly useless. Rough and rude as the lines are, this sketch, with the aid of the dimensions given, would serve the mechanics' purpose as well as a careful instrumental drawing, because it contains precisely the same lines and figures which would be found in such a drawing.

Now, supposing these parts to be given, he who is to make the sketch must be provided with a large pair of calipers and a folding rule (or if great accuracy is required, with a steel scale), for making the measurements. Also with pencil and paper, and if time be an object, with a pair of pencil compasses.

In the latter case, the most expeditious process is to draw first the center lines *A B*, *C D*, *E F*, using the scale as a ruler; next with the compasses to draw the circles of the shaft and the crank pin and their hubs; and finally to make the outlines of the side view also by the aid of the ruler, using the compasses too, to fix the diameter of the hubs, the shaft and the pin. All this, in the case of so simple a subject, even the beginner can do without any outrageous disproportion, even if no measurements be made beforehand. The various parts are then to be carefully measured, and the dimensions one after another put upon the sketch already made.

It will be seen that the distance from the center of the shaft to the center of the crank pin can not be taken directly; but by measuring on the face of the crank from the lower edge of the collar to the lowest point of the shaft, we find the distance *x y* to be 19 in. From this subtract 4 in., the radius of the shaft, and to the remainder add 3 in., the radius of the collar, and we obtain the desired distance, 18 in.

Similarly, the length of the crank pin proper is 5 1-2 in.; the half of this, 2 3-4 in, plus 3-4 in., the thickness of the inner collar, gives 3 1-2 in. as the distance of the face of the crank from the vertical line *H K* through the center of the crank pin. This is an important line, being the plane of rotation, which passes through the center line of the cylinder; from this plane all side distances are estimated, such for example as the 16 1-2 in. to the nearer of the two collars on the main shaft, which limit its journal, 12 in. in length.

Now, it is very frequently the case that distances of vital importance can not be taken at all except by this roundabout process of making several indirect measurements, and adding some and perhaps subtracting others. And in connection with this, there is one feature to which we would call attention in the most emphatic manner, viz.: Having thus determined one required distance, it is a not uncommon case that in determining another one in a similar manner, a second set of figures is obtained, by manipulation with which the first distance can also be determined in another way. When this occurs, it would be a very awkward thing if upon making an instrumental drawing from the sketch the two values thus obtained should not be the same. The utmost care should therefore be taken to test this question while making the sketch—the figures should be compared, and if any discrepancy be detected, the observations should be repeated until the error is eliminated and the results made concordant.

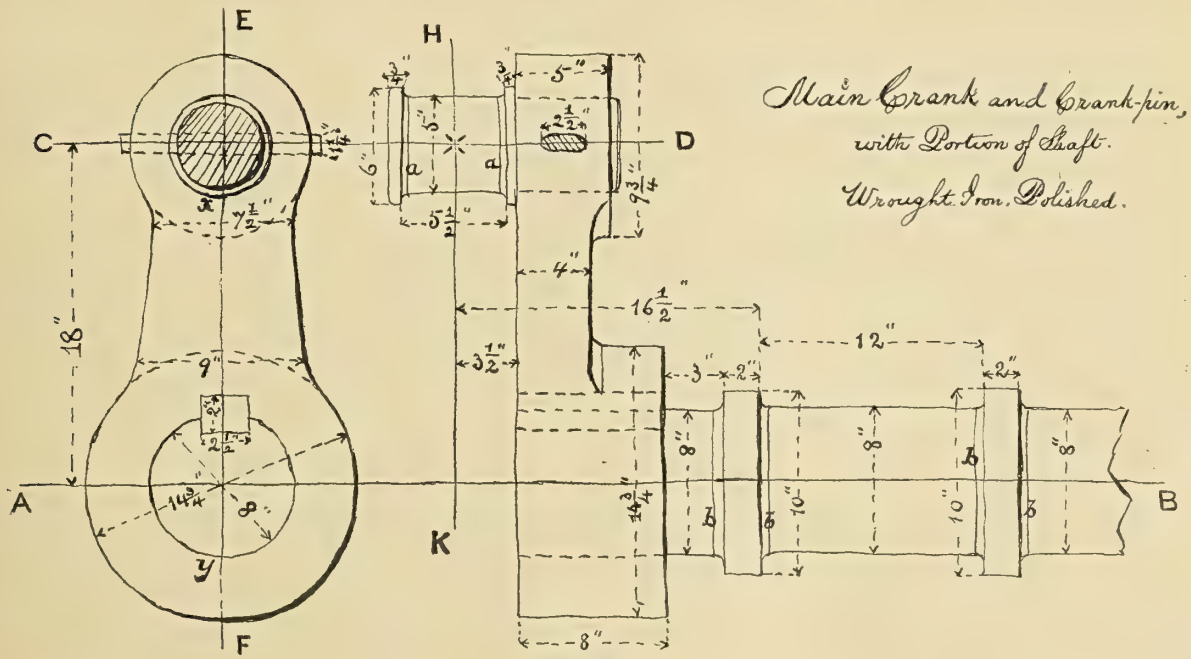


FIG. 28.

It is a well known fact that if a sharp corner, even a right angle, be formed at the junction of either a shaft or a crank pin with collars formed upon it, the liability to fracture is very much greater than if these junctions are rounded out, or, as it is technically called, *filleted*, as shown in the figure. The line of tangency between the fillet and the cylindrical body of the shaft or the pin is, abstractly speaking, an imaginary line, and therefore not entitled to be represented on the drawing. But if it be not shown, the existence of the fillet might be overlooked; particularly if, as is often necessary, its radius be small. But even a very small fillet is a great safeguard against fracture; and the chance of its being overlooked is absolutely prevented by drawing in, *in a hair line*, this imaginary line of tangency, as shown at *a a* on the crank pin, and *b b* on the shaft. There may be two opinions as to whether this improves the appearance of the drawing; but any one whose experience includes the breaking of a shaft by reason of its omission, will thereafter be inclined to think that it does.

Opinions also vary as to the methods of representing center lines and "dimension lines;" we prefer the style shown in the figure, where the center lines are drawn *full*, but very *fine*, while the dimension lines are drawn with *fine dashes*, less pronounced than those used for representing hidden outlines. As to the arrangement and location of the figures, the sketch illustrates one or two principles of general application, viz.: Each figure should be so placed as to be conspicuous—when it can be avoided, figures should not be placed near each other, or near any center line or any outline; and they should be so clearly written that all can be easily read, without the possibility of mistake.

Now, as intimated in the foregoing, the pieces in question could be reproduced by the aid of the sketch, whether in making it the proportions were preserved or not; provided only that the dimensions be clearly and correctly given. But obviously that sketch is the best which most closely resembles the exact drawing; and for several reasons it should be made to do so as nearly as may be, if time permits. For one thing, the habit of close observation is cultivated; and besides, impressions of relative dimensions are insensibly fixed in the mind, and what may be called a sense of mechanical proportion is developed; all of which is of the greatest value to any one who has to do with mechanism, and especially to a designer, who must at the outset depend to a great extent upon free hand sketches as records of his ideas. The ability to sketch in reasonably good proportion is to some extent a natural gift, but like many others it is one which can be cultivated, and greatly improved by practice; and we shall subsequently have occasion to indicate some lines in which such practice may be advantageously pursued with that object in view, without the aid of any artificial appliance.

But, confining our attention now to the production of a fair sketch of the crank and shaft shown in the cut, and supposing a reasonable time to be at disposal, the beginner will find his labor greatly lessened by the use of "cross section" paper; that is, paper divided into small squares by vertical and horizontal lines, either water marked or very faintly ruled; lines at regular intervals being made more pronounced, thus dividing the paper into larger squares for facility in counting the divisions; which may now be had in great variety, in single sheets, pads, and note books, of different sizes. If this be at hand, it is obviously the better course to begin by taking the leading dimensions, before drawing any lines upon the paper; because these can then be put in, by the aid of the subdivisions, very nearly if not absolutely at their proper relative distances from each other. And the minor details being in like manner also measured before they are drawn in, the whole sketch may be made in such a manner as to approximate quite closely to a drawing made to scale.

This will necessarily occupy somewhat more time than the proceeding first described; but on the other hand the result is very likely to be better. And no matter which method be pursued, it should always be kept in mind, that such a sketch is to be considered as a permanent record, and it should be such that a working drawing can be laid down from it, by either the one who made it, or by any one else, *at any subsequent time*. Too many tyros are apt to think that they themselves are to make the scale drawing, and to do it immediately; thus they content themselves with sketches so crude and obscure that no one else could ever use them, and they could not do so themselves two days after—an error which we hope that none of our readers will ever commit.

Current Matters of Interest.

An order for a large side wheel excursion steamer is reported placed with the Detroit Dry Dock Co. for the White Star line of Detroit.

An order for a 140 ft. steam yacht is reported to have been placed with Pusey & Jones, Wilmington, Del., by J. Rogers Maxwell, of New York.

The protected cruiser Chitose, built by the Union Iron Works for the Japanese Government, is reported to have made an average speed of 21.48 knots, with natural draft, on a six hours' run.

New York City is the owner of a considerable fleet of vessels. These are employed in the Police, Fire, Charities, Correction and Dock departments, and include a great variety of types of vessels. The gross value of these vessels is about $1,000,000, and they require an annual expenditure of about $150,000 to keep them in repair and pay the crews and purchase stores.

Returns for the year 1898 will probably show that the amount of tonnage entered and cleared at the port of New York will exceed that of any other port in the world. The number of entries from foreign ports at New York for the year, of all class of vessels, were 4,660, of which number 751 were American vessels. The total of British vessels was 2,573, of which 1,844 were steamships.

Improvements which have been made in recent years in the arrangements for carrying cattle on vessels are indicated by the record made by the S. S. Georgic. On the completion recently of her thirteenth round voyage across the Atlantic her record showed that she had carried more than 11,000 head of cattle without the loss of a single beast. In former years the percentage of losses of cattle on the hoof in the Atlantic trade was enormous.

It is Reported

That the torpedo boat Rowan, constructed by Moran Bros., of Seattle, showed a mean speed of over 27 knots for an hour's run on preliminary trial. Her estimated contract speed is 26 knots. She is a 170 ft. boat, with twin screw quadruple-expansion engines.

That the torpedo boat Davis reached a speed of 23 1-2 knots on her second trial. She was built at Wolff & Zwicker's yard at Portland, Ore. She is 146 ft. long and displaces 132 tons. Her contract speed is 22.5 knots, with 1,750 H. P. She is fitted with triple-expansion engines and Thornycroft water tube boilers.

That a new steamship line will be established between Norfolk, Va., and South American and West Indian ports, the company to be known as the South Atlantic Steamship Co. The promoters claim that many of the shipments now made, via New York, will, upon the establishment of the line, go by way of Norfolk.

QUERIES AND ANSWERS.

(Communications intended for this department will not receive attention unless accompanied by the full name and address of the sender, which will be considered confidential).

Q.—How can I find the clearance of an engine by the indicator diagrams? Also please give method for finding the evaporation by the indicator diagram. Kindly go into detail about clearance especially. I have a 25 in. by 40 in. by 68 in. by 42 in. engine that I have taken some splendid diagrams from and under actual test of weighing coal, etc., driving hard in a heavy head sea, worked down as low as 1.7 per horse power. GREAT LAKES.

A.—The determination of the clearance from the indicator diagram proceeds upon the assumption that the expansion or compression curve is a simple hyperbola. This is a wholly unsafe assumption to make, and the result is likely to be entirely misleading and worthless. These curves depend upon a variety of circumstances and frequently they depart very considerably from the simple hyperbola in form. They are affected by varying amounts of water suspended in the steam, by the action of steam jackets if provided, by leaks in steam valve, or in the piston, etc. With the expansion curve a slight departure from the common hyperbola will be enough to make a very considerable error in the clearance as determined by this method. With the compression curve the departure is often very considerable, so that here also the basis of the method is entirely unreliable. If in the cases you have tried the value in the H. P. cylinder comes out about as it should, it is largely a matter of chance and means presumably that under the especial circumstances the curve is nearly hyperbolic. In the I. P. and L. P. cylinders the method is, in principle, no less nor more accurate than in the H. P. It must be remembered in any case that use can be made only of that part of the expansion curve after cut off and before release, or of that part of the compression curve after exhaust closure and before steam opening. The point of the whole matter is that this method of finding the clearance is wholly untrustworthy, and there is no use in trying to do anything with it. It is a sheer waste of time.

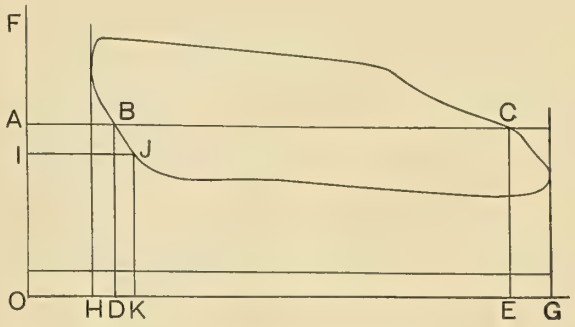
The clearance should be determined either by measurement and computation from the drawings, or by filling it with water and measuring the amount required. There are several methods of procedure. In the first place the valve must be disconnected and blocked in mid position, thus covering the ports. Care must also be taken to provide by the use of putty, if necessary, against leakage at either the valve or piston. Then place the engine on the center and by means of the indicator pipe fill the clearance volume with water by pailfuls, weighing each pailful before pouring in, and the amount left over in the last pailful. Then knowing the weight of the pail, the total weight of water poured in may be found. This reduced to volume by taking 62.5 lb. to the cubic foot will give the clearance volume in cubic feet, and this divided by the volume of the piston displacement will give the clearance percentage. If salt water were used, 64 instead of 62.5 would be used in reducing to volume.

Somewhat differently the mode of procedure may be as follows: Place the engine just one inch off the center as shown by measurements on the guides. Fill up the volume as before and note the weight required. Then move the engine up to the center slowly, catching the water as it is forced out and weighing as before. The amount forced out corresponds to 1 in. of piston displacement. Subtract this amount from the total, and the remainder represents the water in the clearance. Divide the latter by the amount representing one inch of piston travel, and the quotient is the number of inches corresponding to the clearance. This divided by the stroke will give the clearance percentage.

As an illustration of the first mode of procedure, suppose dia. = 22 in., stroke = 40 in., weight of water to fill clearance = 85 lb. Then volume of clearance = 85 ÷ 62.5 = 1.36 cu. ft. The volume of piston displacement = 3.1416 × 11 × 11 × 40 ÷ 1728 = 8.8 cu. ft., nearly. Hence clearance percentage = 1.36 ÷ 8.8 = 15.45 per cent.

For the second mode of procedure let the figures be as follows: Total weight of water with engine 1 in. off center = 99 lb. Weight of water forced out when engine is brought to center = 13.5 lb. Difference = 85.5 lb. Then 13.5 lb. represents 1 in. of piston travel, and 85.5 lb. the whole clearance. Hence 85.5 ÷ 13.5 = 6.33 in. = number of inches of piston travel giving a volume equal to that in the clearance. Hence 6.33 in. ÷ 40 in. = 15.8 per cent = clearance percentage.

In regard to the second question, the evaporation derived from the indicator card is also inaccurate, misleading and worthless, unless it is remembered that it shows simply the amount of water present in the form of *vapor* and not the total amount of mixed *water* and *vapor*. This total amount may be from nothing to 50 or 100 per cent greater than the amount of vapor, depending on circumstances, and at what point of the card the determination is made. Remembering then that this determination relates simply to the amount of vapor, and not to the total amount of water in the form of both liquid and vapor, we may proceed as follows: Referring to the figure here printed, we draw



the line of zero pressure, absolute, and the clearance line *O F* such that *O H* ÷ *H G* equals the clearance percentage as determined by computation or measurement. We then select a point *C* on the card just before the point of exhaust opening, and draw the line *A C*. This line represents the total volume of steam at a pressure *E C*, present in the cylinder at this point of the stroke. Of this total amount, a certain part is rejected during exhaust, and the remainder is shut in by the exhaust closure. When the latter has been compressed up to the pressure *D B* equal to *E C*, the volume occupied is *A B*. Hence the amount actually exhausted corresponds to a volume *B C* at pressure *E C*. The volume of total piston displacement is represented by *H G*. Hence the volume represented by *B C* is the same fraction of the piston displacement that the length *B C* is of *H G*. In this way the volume corresponding to *B C* is found. Then from steam tables we find the weight per cubic foot at the pressure *E C*, and multiplying this by the volume, we have the steam per stroke in this end of the cylinder. This entire operation must then be repeated and the corresponding amount found for the other end of the cylinder. The sum will be the amount per revolution, and then from the known revolutions per minute or per hour, the amount per minute or per hour may be found, and dividing the latter by the I. H. P. we shall have the amount per I. H. P. per hour. In some cases the best point at which to take the amount of compression steam may seem to be other than *B*, as at *J* for example. In such case the amount of compression steam is taken as that corresponding to the volume *I J* and pressure *K J*, and is subtracted from that corresponding to volume *A C* and pressure *E C*. If desired the volume of the piston rod may be allowed for in finding the volume of piston displacement in the head end.

As an illustration take the following relating to the H. P. cylinder of a triple-expansion engine: Dia., 22 in.; stroke, 40 in.; dia. of piston rod, 5 in; clearance, 15 per cent.

Then:

Volume of piston displacement, head end = 8.80

Volume of piston displacement, crank end = 8.35

For head end let *B C* = 3.45 in. and *H G* = 4 in. Then volume corresponding to *B C* = 3.45 ÷ 4 × 8.8 = 7.59. Let the pressure *E C* be 80 lb. above atmosphere or 95 lb. absolute. Then weight of 1 cu. ft. at this pressure as given by steam tables is .2165 lb.

Hence:

Weight of steam in head end for one stroke = .2165 × 7.59 = 1.643. For crank end let *B C* = 3.3 in. and *H G* = 4 in. Then volume corresponding to *B C* = 3.3 ÷ 4 × 8.35 = 6.89. Let the pressure *E C* be 82 lb. above atmosphere or 97 lb. absolute. Then weight of 1 cu. ft. at this pressure as given by steam tables is .2208 lb.

Hence:

Weight of steam in crank end for one stroke = .2208 × 6.89 = 1.521. Then weight of steam per revolution = 1.643 + 1.521 = 3.164. The revolutions were 88 per minute and the total I. H. P. developed by the engine was 1,544. Hence the steam per I. H. P. per hour as accounted for by the H. P. indicator card is:

$$\text{Weight} = \frac{3.164 \times 88 \times 60}{1544} = 10.82 \text{ lbs.}$$

The actual steam consumption in this case was about 14 lb. per I. H. P. per hour, so that the steam thus accounted for by the indicator is only 10.82 ÷ 14 or 77 per cent of the whole amount.

Q.—Please figure these out:

For compound condensing engines with two or more cylinders when the cranks are not overhung:

$$S = \sqrt[3]{\frac{C \times P \times D^2}{f\left(2 + \frac{D^2}{d^2}\right)}}$$

$$P = \frac{f \times S^3}{C \times D^2}\left(2 + \frac{D^2}{d^2}\right)$$

Where S = diameter of shaft in inches; d^2 = square of diameter of high pressure cylinder in inches or sum of squares of diameters when there are two or more high pressure cylinders; D^2 = square of diameter of low pressure cylinder in inches or sum of squares of diameters when there are two or more low pressure cylinders; P = absolute pressure in pounds per square inch, that is, boiler pressure plus 15 lb.; C = length of crank in inches; f = constant from the table.

Note.—Intermediate pressure cylinders do not appear in the formulæ.

For ordinary condensing engines with one, two or more cylinders when the cranks are not overhung:

$$S = \sqrt[3]{\frac{C \times P \times D^2}{3 \times f}}$$

$$P = \frac{3 \times f \times S^3}{C \times D^2}$$

Where S = diameter of shaft in inches; D^2 = square of diameter of cylinders in inches or sum of squares of diameters where there are two or more cylinders; P = absolute pressure in pounds per square inch, that is, boiler pressure plus 15 lb.; C = length of crank in inches; f = constant from table.

The first is a fore and aft compound engine of 28 in. dia. high pressure and 54 in. dia. low pressure cylinders with 36 in. stroke. Steam pressure at boiler 136 lb.; angle between cranks 90 deg. $f = 1047$.

The second is a double condensing engine with cylinders 24 in. dia. and 21 in. stroke; steam pressure 93 lb.; angle of cranks 90 deg. $f = 1047$. CANADA.

A.—The formulae which you quote are the British Board of Trade Rules. For the first case we have the following values:

$d = 28$
$D = 54$
$C = 18$
$f = 1047$
$P = 136 + 15 = 151$

We find first the square of d or 28, which is 784, and the square of D or 54, which is 2916. We then divide 2916 by 784 and find 3.72 for the value of $D^2 \div d^2$ in the denominator. To this we add 2 and find 5.72 as the value of the parenthesis in the denominator. We then multiply together 18 × 151 × 2916 and divide by 1047 × 5.72, finding 1323.+ as the result. We next take the cube root of this number and find 10.98 inches. Taking the nearest shop figures we should have 11 in. as the diameter of the shaft.

For the second case the values are:

$D = 24$ and $D^2 = 576$
$C = 10.5$
$P = 93 + 15 = 108$
$f = 1047$

We then multiply 10.5 × 108 × 576 and divide by 3 × 1047, or 3141, finding 207.9 as the result. We then take the cube root of this number and find 5.92 in. Taking the nearest shop figures we should have 6 in. as the diameter of the shaft.

Q.—How is it that a small engine turning, say, 300 or 400 revolutions per minute will develop more horse power than an engine with cylinders over twice the size but only turning, say, 150 revolutions per minute, the steam being the same? Does it mean that the small engine could drive a boat as fast as the larger one? H. M. M.

A.—*Horse power* means a certain amount of work done per minute, and *work* depends on two things—pressure or load and speed or distance traveled per minute. To illustrate, suppose you are hoisting bricks by hand with a simple block and fall, and you hoist 100 lb. 30 ft. high in one minute. Then you have done 30 × 100 or 3,000 ft. lbs. of work. If you hoisted 70 lbs. 50 ft. the work would be 3,500 ft. lb. If the load was 50 lb. and the height 60 ft. the work would be 3,000 ft. lb. as at first. What you have lost in the load you have made up in distance. Similarly if the load was 200 lb. and the height 15 ft. the work would still be 3,000 ft. lb. What is lost in height is made up in load. The same with the two engines. Suppose the mean pressure and stroke to be the same, the cylinder area for the first to be 40 sq. in. and revolutions 150, while cylinder area for the second is 20 sq. in. and revolutions 300. Then the power developed will be the same in each case. What the larger engine loses in revolutions it makes up in area of piston, and so in total pressure or load. If the small engine should make 400 revolutions, then the power developed would be greater than for the larger engine at 150 revolutions. With the first engine at 150 revolutions and the second at 300, each fitted to a properly designed propeller, the speed of boat would be the same, provided of course that each propeller had the proper immersion.

Q.—Please add to the answer in the January issue something about wooden vessels. KEY WEST.

A.—Well, instead of the bowl made of sheet iron take a bowl made of light wood, say yellow pine, and bore a hole in the bottom. Water enters, but the bowl still floats. Why? Simply because the wood floats naturally. That is, its weight is less than that of an equal volume of water, and hence the necessary buoyancy is gained by the displacement of the material of the bowl before the immersion is complete.

The ordinary wooden ship, including fittings, metal fastenings, etc., is usually too heavy to float in this way, and hence will sink when invaded by water. Suppose, however, that we have such a vessel with the hold full of lumber? When water comes in the lumber provides effective displacement, and thus adds to the buoyancy derived from the structure of the vessel. In such case the vessel may float instead of sinking. Why? Simply because the lumber helps displace the water and adds to the available buoyancy, so that the total amount equals the total weight, vessel and cargo, before the immersion is completed. In this way it might be possible for a light steel vessel to float if water-logged with a hold full of light lumber. This is exactly similar in principle to encasing a piece of pine with thin sheet iron. The combination will float, while the iron alone, with water in the inside, will sink.

These general principles apply to all kinds of floating bodies, the battleship, the Atlantic liner, the schooner and the rowboat. The buoyancy must equal the weight, and the ship or boat floats with a good freeboard because a buoyancy equal to the weight is gained before the immersion is complete. Thus a battleship if immersed to the deck-edge would be subject to an upward buoyant force of some 16,000 or 18,000 tons. But as the battleship with all equipments weighs only some 11,000 tons, let us suppose, an upward buoyancy sufficient to balance this is gained with a considerable part of the hull still above the water line.

If the general principles given here and in the previous answer are kept clearly in mind they will serve to explain any and all problems connected with the floating of a body, whether it be simple or complex.

It is understood that the Navy Department will shortly offer for sale a number of the auxiliary vessels purchased during the Spanish war and that the vessels offered will include a number of steam yachts.

A survey of the Government property at League Island is being made, with a view to the construction of a great concrete naval dock there which is to be over 700 ft. long, and wide and deep in proportion. A large dock will also be built at Boston, Mass.

TRADE PUBLICATIONS.

Users of anchors should have a copy of the catalogue just issued by the Baldt Anchor Co., Chester, Pa. This patent anchor has received much attention and has been approved by the Lloyds Register. Several excellent testimonials are given, speaking in the highest terms of the anchor, by those who have given it practical test.

Users of wood working machinery will be interested in an illustrated catalogue of special wood working machinery issued by Baxter D. Whitney, Winchendon, Mass. It is one of the best specimens of the printer's art received in this office for a long time. So much wook working machinery is used in shipyards that this catalogue should be had by all interested.

The latest bulletin issued by the Sturtevant Co., Jamaica Plain, Mass., is devoted to electrical fans and is designated as Bulletin H, which can be had by writing for a copy. It comprises eight pages and is printed in the usual Sturtevant manner, giving a great many varieties of fans, including a special type of suspended fan designed especially for use on board ship.

Draughtsmen and others who have lettering to do will be interested in the pocket sized catalogue devoted to the Tampograph, a device manufactured by the Tampograph Co., Wilmington, Del. It is a simple mechanical device for designing and executing all sorts of hand lettering on drawings, maps, etc. The full operation of the device is explained in the catalogue.

"Who Uses Mechanical Draft?" is the question on the cover of an unusually attractive book issued by the Sturtevant Co., Jamaica Plain, Mass. The question is answered by a very large list of names where either forced or induced draft is used, and includes a large number of vessels in the Navy, besides many of the best known steamships and steam yachts in the country.

Drop forgings, as manufactured by J. H. Williams & Co., Brooklyn, N. Y., receive very thorough attention in a 40-page catalogue just issued. The line of forgings manufactured by this firm is fully described, giving sizes, prices and all other information that could be asked for. It is a very well printed catalogue and is thoroughly illustrated with the best of wood cuts.

"Pencilings" is the title of a very attractive and fully illustrated book issued by the Joseph Dixon Crucible Co., Jersey City, N. J. It gives quite a history of the graphite and pencil industry of the country and gives information which is useful for draughtsmen and other users of pencils. Several pictures in color are also given showing what can be done with colored crayons.

A cloth bound catalogue of more than sixty pages is received from F. Hennebohle, South Chicago and Erie avenues, South Chicago, Ill. Practically every page contains some type of specialties manufactured by this company. Many of these specialties are adapted to marine work. Copy of the catalogue should be in the hands of everybody interested in steam goods.

Lundell Motor Catalogue No. 58 is just at hand from the Sprague Electric Co., 20 Broad street, New York. It is 7 by 9 inches in size and bound in an exceptionally effective cover of rich green paper, printed in red and gold. The catalogue comprises over seventy pages and is fully illustrated with the very best of engravings, and altogether is an exceptionally fine specimen of the printer's art. It contains a great deal of valuable information regarding the subject of electricity, together with tables and other information, making it a valuable publication. A series of pictures is published showing the many special adaptations of motors to machine tools and other uses.

The Barnes Tool Co., New Haven, Conn., illustrates and describes many tools especially adapted to many uses in the marine field in a catalogue just received. These include pipe and other wrenches, a line of sawing machines and steering wheels designed for vessels of all sizes and qualities. These wheels should receive the attention of every yachtsman.

Various rubber goods manufactured by the Revere Rubber Co., 63 Franklin street, Boston, Mass., are well illustrated and described in a set of a half dozen or so folders and catalogues about 3 by 6 inches in size. The packing catalogue should be in the hands of every user of packing, as it is not only neatly printed in two colors, but contains many illustrations of the various kinds of packing made.

Improved lubricating devices manufactured by the Detroit Sheet Metal & Brass Works, Detroit, Mich., are fully described and very neatly illustrated in the catalogue just received. The cover is very dark green, printed in gold letters. There is a full line of lubricators, oil pumps and kindred devices shown, with incidental reference to a line of marine hardware, rafts, ventilators, etc. There is much matter valuable for reference in addition to the above, making the catalogue exceedingly useful.

The Norton patent ball bearing lifting jacks are fully described in a catalogue just at hand. A great many types of jacks are illustrated and much information is given regarding the subject in general and each type of jack in particular, and a number of testimonials are reproduced. There are many uses for jacks in marine work, and those interested in the subject should have a copy of this catalogue, which can be had by writing to the manufacturer, A. O. Norton, 167 Oliver street, Boston, Mass.

Calendars for 1899 Received.

We are informed by the publishers of these calendars that copies can be had on application up to the limit of the supply.

H. B. Leonard & Co., 141 Milk street, Boston, Mass., containing lithographed pictures of the many uses for "Brilliant" metal polish.

West & Peachey, Simcoe, Ont., Canada, containing pictures illustrating the Alligator steam warping tugs manufactured by this firm.

George I. Roberts & Bro., 471 Fourth avenue, New York, a colored lithograph representing the battleship Oregon pursuing the Cristobal Colon.

George B. Carpenter & Co., 202-208 South Water street, Chicago, Ill., a fine 4 by 8 half-tone picture, with the busy sail-loft scene in this firm's establishment.

The William Powell Co., Cincinnati, O., printed in three colors and showing a valve, whistle and other specialties; also a large red star on a brass regrinding valve.

American Steam Gauge Co., 36 Chardon street, Boston, Mass., containing a very artistic color lithograph of two pointers hunting, and framed effectively in a gilt border.

William Bishop's Sons, 205 South street, New York, an embossed calendar in white and gold, containing an excellent picture of the Shakespeare Memorial building at Stratford-on-Avon.

Dearborn Drug & Chemical Works, Rialto Building, Chicago, Ill., two calendars, one large one containing a lithographed picture of old Fort Dearborn, the first building in Chicago; the other a small one, pocket size, printed in gilt on celluloid.

La Favorite Rubber Manufacturing Co., Paterson, N. J., with pictures of Perry packing and other specialties, each month's sheet having an excellent portrait of some Naval Officer or General prominently identified with the recent war.

American Manufacturing Co., 67 Wall street, New York, a very handy desk calendar, 5 by 7 inches in size, printed in blue and bordered with cordage, embossed and gilded. Inside the folder is much important information regarding rope.

BUSINESS NOTES.

LARGE SHIP CHANDLERY CONCERN.—S. P. Blackburn & Co., ship chandlers, with stores in New York, Boston and Philadelphia, have opened a branch house at 502 East Lombard St., Baltimore, Md.

SLIGHT CHANGE IN NAME.—The Lackawanna Lubricating Co., of Scranton, Pa., has extended its business and changed its name to the Lackawanna Lubricator & Mfg. Co., in order to carry on a more extensive business in manufacturing cylinder lubricators and grease cups.

MORE SHOP ROOM.—The Morse Iron Works Co., foot of 26th St., Brooklyn, N. Y., has been so crowded with work that it has taken an adjoining warehouse for use as additional shop room. This increases its capacity very much and greatly improves its facility for rapid and efficient work.

REMOVAL OF OFFICE.—The Philadelphia office of the C & C Electric Co. has been removed from 633 Arch St, to much larger and more attractive quarters at 45 North 7th St. The office will remain in the hands of William Myers, who is well known to the many friends of this company.

TUBE EXPANDERS.—The Ferguson patent self-feed roller-tube expander manufactured by A. L. Henderer's Sons, Wilmington, Del., is illustrated in the advertisement of this company elsewhere. This firm also makes a line of hydraulic jacks and punches, pipe vises and other boilermakers' specialties.

CHANGE IN NAME ONLY.—The business heretofore carried on by William Porter's Sons, 271 Pearl St., New York, in all kinds of lamps and lanterns for marine uses has been changed into a corporation under the name of William Porter's Sons Co. This change became necessary owing to the large increase and extension of the company's business.

AN ECONOMICAL VESSEL.—The owners of the S.S. C. A. Black, 6,800 tons, believe her the most economical freight carrier, not only on the lakes, but in the country. A report of a recent test gave a consumption of 1.46 lb. coal per I. H. P. per hour. This efficiency is largely credited to the Howden hot draft, installed by the Detroit Dry Dock Co., Detroit, Mich.

BUCKLEY WATER TUBE BOILER.—The Buckley water tube boilers, manufactured by the Rochester Machine Tool Works, Rochester, N. Y., have found extensive use in yachts and launches and have been put in many boats for the United States Government. The steaming and other qualities of these boilers are well shown in the circulars sent out by the company to all inquirers.

METAL POLISH.—Ayrolite is a metal polish which has found extensive use in marine trade because of its many features. The loss by evaporation on liquid polishes and melting paste polishes is done away with. Ayrolite is used to polish brightly any finished metal; is guaranteed by its manufacturers free from acids, grease or grit, and not to injure even the finest ware. The sample package offered for 10 cents is believed to be equal to a pint of ordinary liquid polish. It is manufactured by the Ayrolite Co., 625 Second Ave., Pittsburg, Pa.

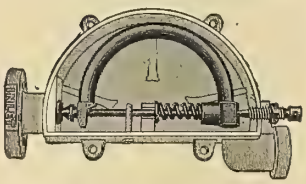
THE PARAGON BOILER.—Reference has been made before in these columns to the Paragon boiler, manufactured by Captain M. De Puy, 19 South St., New York, and to the record of the steam canal boat Paragon propelling herself and towing ten fully loaded canal boats from Albany to New York, the weight of all the cargoes being 3,280 tons. We are now informed that the boiler has proved to be such a big steamer that the grate area has been reduced one-half. The draft has been more evenly distributed and improved by putting retarders in eighty of the upper tubes. The owners of the steamer Paragon have a sister boat which, during a recent test of the two boats, burned 43 tons of soft coal in 30 days against 16 tons for the Paragon, doing similar work.

Efficiency

makes the value of the "Heintz" Steam Trap—lots of others where you get more iron for your money—lots of imitations, too—and some of them look almost exactly like the "Heintz."

Every puff of steam you lose means a loss of more or less money-profits gone. Use the "Heintz" on your outlets, wherever steam escapes, and you will have an increased boiler capacity. We have saved some concerns large sums—more than we dare say. Can save you something, too.

The cost? Of little moment when traps are needed. Booklet "G" tells the starting point. Get one from us.



William S. Haines Company,

136 S. 4th St., Phila.

"The Heintz—the best—tho' it has imitators."

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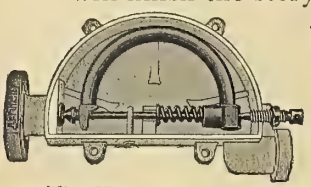
Labor or Steam

wasted in your plant? Suppose you had a hundred men on your pay roll, and fifteen to thirty doing nothing—"air punchers"—how long before you would weed them out? Yet, that's your proportion of loss in power when you run a plant without the "Heintz" Steam Trap.

Automatic, silent, economical, lasts a lifetime. Only six parts besides the case—can't wear out. No levers, floats, air valves or theories—just plain mechanics. Sent on thirty days' trial on request. Booklet "G" will finish the story. Want it?



William S. Haines Company,

136 South Fourth Street, Philadelphia.

"The Heintz—the best—tho' it has imitators."

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Graphite Lubrication

There is no substance known so smooth or so enduring as **Dixon's Pure Flake Graphite.** It is the best solid natural lubricant ever discovered. It is not affected by heat or cold, acids or alkalies. It is absolutely indispensable to every marine, stationary or locomotive engineer.

Largely increases the lubricating value of all oils or greases.

Will cool bearings and stop "groaning" or squeaking when all other lubricants fail.

It will pay you to send for Sample and Pamphlet. No charge.

JOSEPH DIXON CRUCIBLE CO., Jersey City, N.J.

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PATENT DEPARTMENT

THE POWER PUBLISHING CO.,
WORLD BUILDING, NEW YORK.

REDUCING VALVES

to control or reduce steam, water or air pressures.

"MASON"

Valves have had a world-wide reputation for years.

Write for prices.

THE MASON REGULATOR CO.,
BOSTON, MASS.

ALMY BOILERS.—A fine steam yacht recently ordered by D. W. & A. C. James, of the New York Yacht Club, will have, among other features, Almy boilers, furnished by the Almy Water Tube Boiler Co., Providence, R. I.

A MINIATURE ANCHOR.—The Baldt Anchor Co., Chester, Pa., is sending out to its friends a model of the Baldt stockless patent anchor, about 1 1-4 in. long. It is nickel plated and makes a very novel and attractive souvenir. All readers of Marine Engineering who wish one need only to send their name and address and refer to this publication.

THE TRIGG SHIPBUILDING CO.—The Trigg Shipbuilding Co., Richmond, Va., which was only formally organized a few weeks ago, has already begun work on the three torpedo boats which it has contract for. The plant is in full working order and a full force is now in active work, giving the company every facility for branching out and filling any orders that may be received.

QUARTET CHIME WHISTLE.—Every user of a steam whistle will be interested in the one manufactured and advertised by the Kinsley Mfg. Co., Bridgeport, Conn. This is intended to be as musical a whistle as can be made and has been introduced into many of the best yachts and steam vessels in the country. A good sounding whistle is of such importance that all interested will no doubt want to investigate.

AN EFFICIENT LAUNCH.—The Daimler Mfg. Co., Long Island City, N. Y., is in receipt of a letter from W. A. Thompson, U. S. Engineers' Office, La Crosse, Wis., which says that a 21-ft. 2 horse-power Daimler launch purchased in 1893 has been used for nearly six years on work for improving the Mississippi river and has been run about 25,000 miles with excellent satisfaction. This certainly is a high compliment to the Daimler engine and hull.

BOILER COMPOUND.—The Dearborn Drug & Chemical Works, Rialto Building, Chicago, Ill., have established a marine department, under the charge of E. P. Gould, a marine engineer of much experience. In order that the compound furnished for each case shall be adapted to the needs of the ship, the company offers to analyze without charge samples of water sent in and to supply compound designed to overcome the impurities of a sample. The purpose of the department is to reduce corrosion and injury to marine boilers to as low a point as possible, and as much attention is given to the seacoast as to the lakes. One of the formulae is designed especially to reduce the injurious qualities of salt water to a minimum when it is necessary to use this in a boiler. Further information regarding the marine department can be had from the company.

PROSPERITY AT HARLAN & HOLLINGSWORTH'S.—At a recent meeting of the Board of Directors of the Harlan & Hollingsworth Co., Wilmington, Del., to fill the vacancy in the office of president, caused by the death of the late J. Taylor Gause, H. T. Gause was elected president, H. W. Gause vice-president and secretary, and J. Rodney Gause to the vacant directorship. The above, with S. K. Smith, treasurer, and T. Jackson Shaw, superintending engineer, completes the Board of Directors. The following changes have also been made in the organization of the plant: W. F. Carnos, assistant superintending engineer; E. B. Sadtler, superintendent of hull construction; J. Rodney Gause, assistant superintendent of hull construction; Thomas Benson, superintendent of dock repairs. This company has recently received a contract from the New York and Porto Rico S.S. Co. for a sister ship to the "Ponce," and from the Red D Line for a twin screw freight and passenger steamer, 277 ft. long. During the year 1898 this company signed many contracts for vessels, making the record one of the best in its history. A large amount of new machinery has recently been added to the establishment, and in every way the equipment of the whole yard has been brought up to a high state of efficiency.

Launch Outfit.—A compact and convenient power plant for launches and other uses where a small power plant is required is advertised elsewhere by the Shortt Engine Co., 143 Liberty St., New York. Detailed information can be had by inquiring of the company.

Cold Process of Galvanizing.—The U. S. Electro Galvanizing Co., 346 Broadway, New York, is finding many users of its cold process for galvanizing. In addition to its commercial work, it is doing work for the U. S. Navy. This system widens the use of galvanizing.

Clean Oil.—The Famous oil purifier, manufactured by the Famous Filter Co., 314 North Main St., St. Louis, Mo., is used extensively in many manufacturing establishments, as well as by the United States Navy. This filter is guaranteed to extract impurities and is sent on 60 days' trial.

Two Fine Launches.—The International Navigation Co. has ordered from the Marine Vapor Engine Co., Jersey City, N. J., two specially built 30-ft. launches equipped with 12 horse-power Alco engines, to be used as tenders for the S.S. New York, which is about to make a cruise through the West Indies with excursionists.

Crumlish Forges.—We are informed that 46 per cent of the forges built by the Crumlish Forge Co., Buffalo, N. Y., in 1898 were supplied to shipyards on the lakes and along the seacoast. The demand for these forges has so increased that the company has moved to much larger and better equipped quarters at 18-20 Elk St.

A Big Casting.—The Penn Steel Casting & Machine Co., Chester, Pa., recently received an order for a rudder for the S.S. Kensington. The casting, 28 1-2 ft. wide, weighing over ten tons, was ready in less than the fourteen days given in which to finish the work, demonstrating the capacity of this company to give prompt attention to the orders of this kind.

Loss by Fire.—Caskey Bros.' foundry, Newport News, Va., was destroyed by fire last month, causing serious loss, especially as the company was full of orders at the time. The loss is placed at about $20,000, covered by insurance. The company will undoubtedly be able to resume business soon and be able to fill all orders for Caskey's manganese bronze and white lining metal.

ZINC WHITE IN MARINE PAINTING.

Within a few years after the discovery of the modern process for making zinc white, the French naval authorities, after severe tests, ordered its use to the exclusion of white lead on the interior of all vessels of the French navy. Experience has confirmed its superiority for painting structures exposed to sea-air and sea-water, and the French navy as well as the French steamship companies now universally employ it, while it is also the official base for painting lighthouses and Government work on the seashore. The French Marine authorities also use it for painting galvanized iron plates, the hulls of torpedo boats, the shells of metal pontoons, etc.

That the French navy should have been earliest to adopt this practice is natural, since zinc white was first generally introduced in France. But the naval authorities of the United States, having made their own experiments with the same results, have adopted zinc white as the fixed component of all paints used either in the Navy or by the Lighthouse Establishment. The famous "White Squadron" obtained its color from zinc white, and remained white because zinc does not change color. Ten tons of American zinc white is the cruising allotment for each ship, and it is used liberally and effectively.

Similar testimony is found in the U. S. Lighthouse specifications, which require, for white, a mixture of one-fourth lead and three-fourths zinc, and for tinted paints, American zinc white and yellow ochre, with no lead. "The colored paints are wanted for outside use and are required to withstand the bleaching effects of salt water and sunlight."

The durability of zinc white is due to its chemical stability and to the large proportion of oil it carries to the painted surface. No other white pigment approaches it in this respect. It is the one white paint material that is capable of resisting salt water and salt air. Added to other materials it shields them and gives them durability.

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Useful Notes is the name of a little pamphlet filled with information for transatlantic travelers and published by Pitt & Scott, 37 Broadway, New York. This firm is one of the best known tourist agents and private express companies, and long experience in this particular field has enabled it to know just what sort of information the intending traveler needs. It is a compact little book, to be carried in the waistcoat pocket. Copies can be had by applying to the firm.

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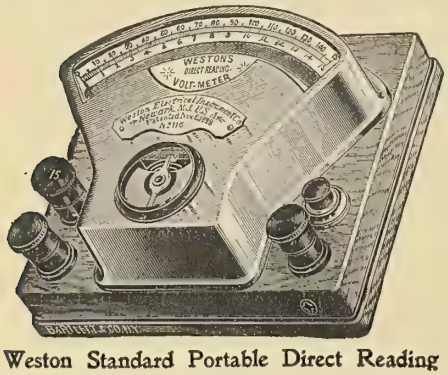

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